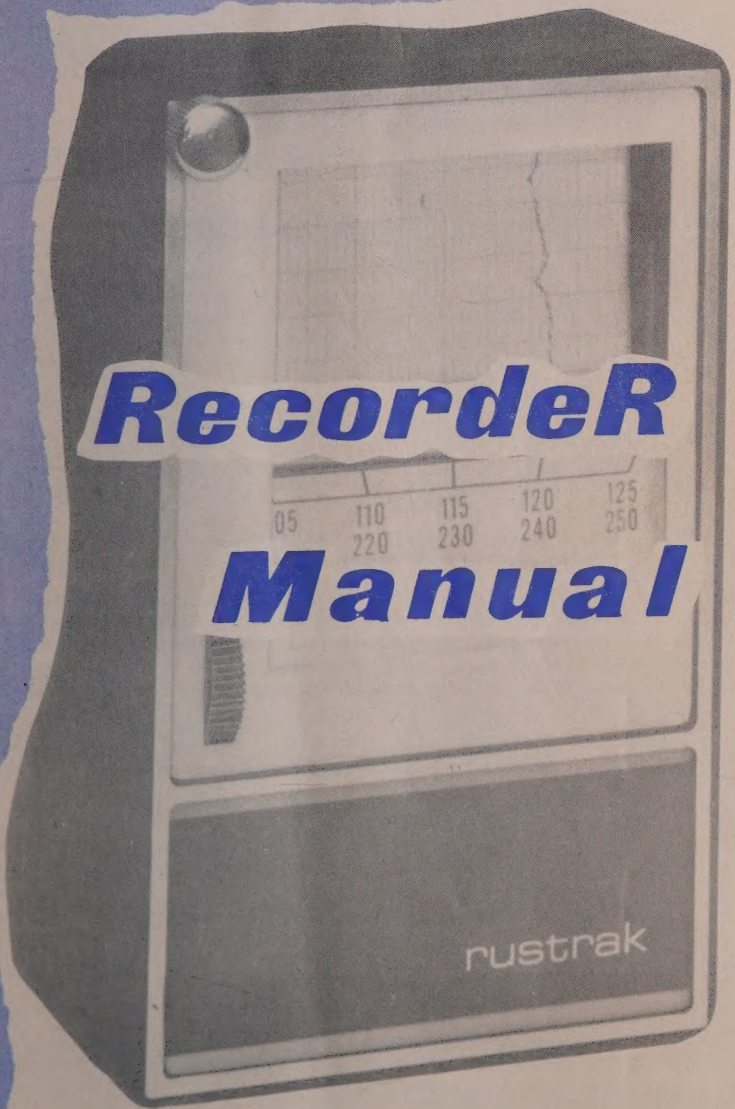
Sales RI (401 884 6800)

" 200 " SERIES



RecordeR Manual

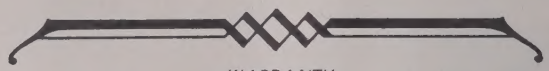
rustrak Instrument Div.
Gulton Industries Inc.
Municipal Airport • Manchester, N.H. 03103
Telephone (603) 623-3593 • Twx 710-220-1878

3593

Local Dist Gradient 4233422

This Operator's manual was prepared to assist you with the basic operation of your recorder; its care, its potential . . . and the unique features that enhance its versatility.

Please read this manual carefully. A few minutes of study NOW will show you how your recorder can serve you best.



WARRANTY

Rustrak warrants each instrument of its manufacture to be free from defects in material and workmanship under normal usage and service for a period of one year after its initial purchase from the factory or an authorized Rustrak representative or distributor. Our obligation under this warranty is limited to repairing or replacing any instrument or component which, upon examination by factory personnel, is found not to conform to the foregoing warranty providing said instrument is returned to the factory, transportation prepaid. We shall not otherwise be liable for any damages, consequential or otherwise.

The foregoing warranty is exclusive and in lieu of all other warranties whether expressed or implied.

LIMITATIONS

This warranty does not apply to galvanometer stylus damage caused by improper chart installation, damages resulting from transportation, alteration or misuse. Rustrak reserves the right to discontinue any model at any time or change specifications or design without notice and without incurring any obligation.

This booklet was prepared by the
TECHNICAL PUBLICATIONS DEPARTMENT
of Rustrak Instrument Division, Gulton Industries, Inc.
Manchester, N. H. 03103

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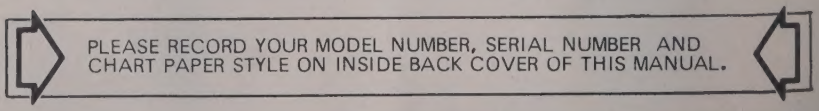

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rustrak Instrument Div.
Gulton Industries Inc.

PUBLICATION 31069

INSTRUMENTS DISCUSSED IN THIS MANUAL ARE PROTECTED BY U.S. PATENTS Nos. 3,048,848 - 3,129,998 and 3,170,754.

RECEIVING INSTRUCTIONS

Unpack your instrument and accessories with care. The following items are supplied with each recorder:

- ☐ 1 - Cardholder
- ☐ 2 - Brackets, Panel Mounting
- ☐ 2 - 8-32 x 1/4" Pan Head Screws
- ☐ 2 - 8-32 x 5/16" Pan Head Screws
- ☐ 2 - Speed Nuts
- ☐ 4 - Rubber feet
- ☐ 4 - 4-40 x 1/4" Pan Head Screws
- ☐ 1 - Cardboard Sleeve (mounted internally, if instrument ordered for reroll)
- ☐ 1 - Matching Connector S3306-08-CCT (if applicable)

If some items are missing, please double check all packing material. Notify your carrier immediately if obvious damage has occurred in transit. Ask him to examine goods, whether or not the shipping container is intact.

DO NOT DESTROY PACKING MATERIAL OR CONTAINERS UNTIL YOUR AGENT HAS EXAMINED THEM.

Under U. S. shipping regulations, damage claims must be collected by the consignee. Don't return merchandise damaged in shipping until your claim is established.

GENERAL OPERATING INSTRUCTIONS

BEFORE OPERATING YOUR RUSTRAK RECORDER:
Refer to Chart Loading and Installation Instructions in this manual.

AFTER LOADING:

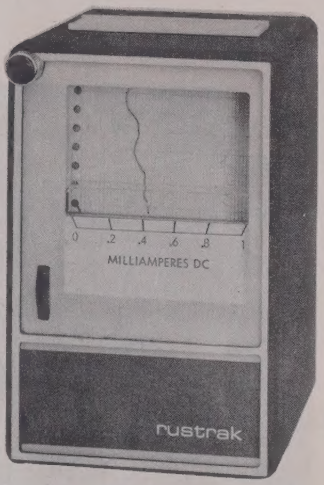
1. **Chart should be set to time desired. To set chart to correct time, press in and roll down Chart Advance Thumbwheel. Always set time at striker bar level where trace is printed, never to top of stylus.**
2. **Be sure supply and signal connections are correct. Refer to Installation Section before operating.**
3. **Apply power.**
4. **Recorder needs no further attention until chart paper supply is depleted.**

YOUR RUSTRAK RECORDER....

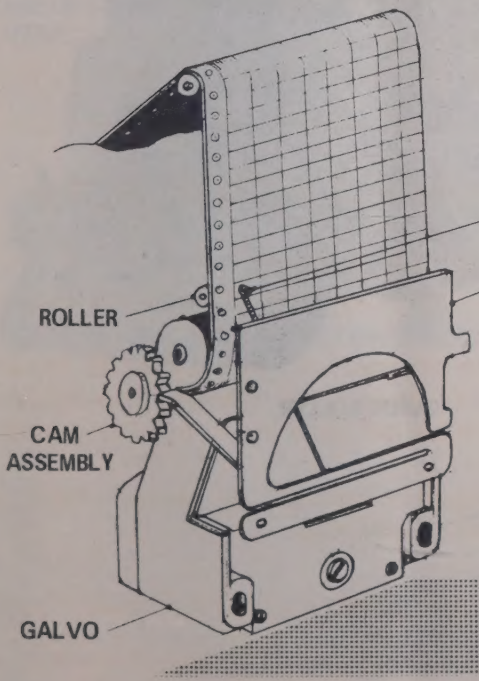
DESCRIPTION

The heart of your Rustrak recorder is its galvanometer. Basically a D'Arsonval movement, it is fed directly on basic ranges but uses appropriate shunts and multipliers for higher current and voltage ranges. Dual channel recorders use two galvanometers while AC instruments have bridge circuit rectifiers.

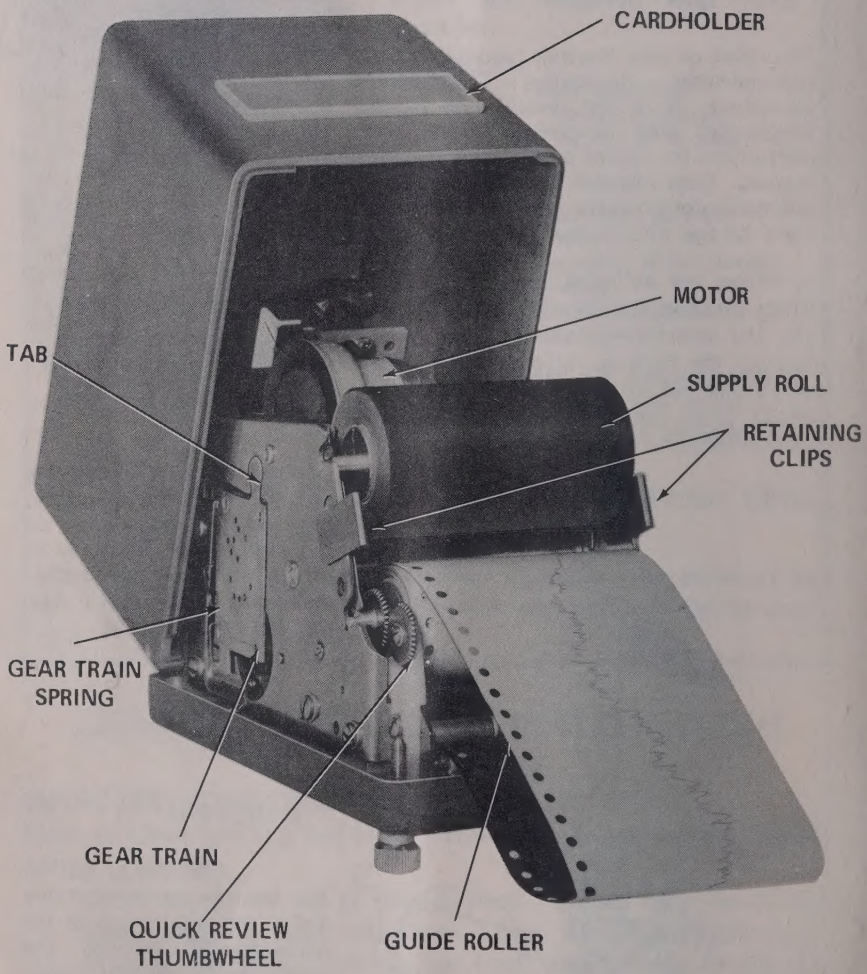
A striker bar actuated by a cam on the motor presses against the stylus, marking the pressure-sensitive chart paper against the back-up roller. The number of strikes per second depends on motor speed since the number of teeth on the cam is fixed.

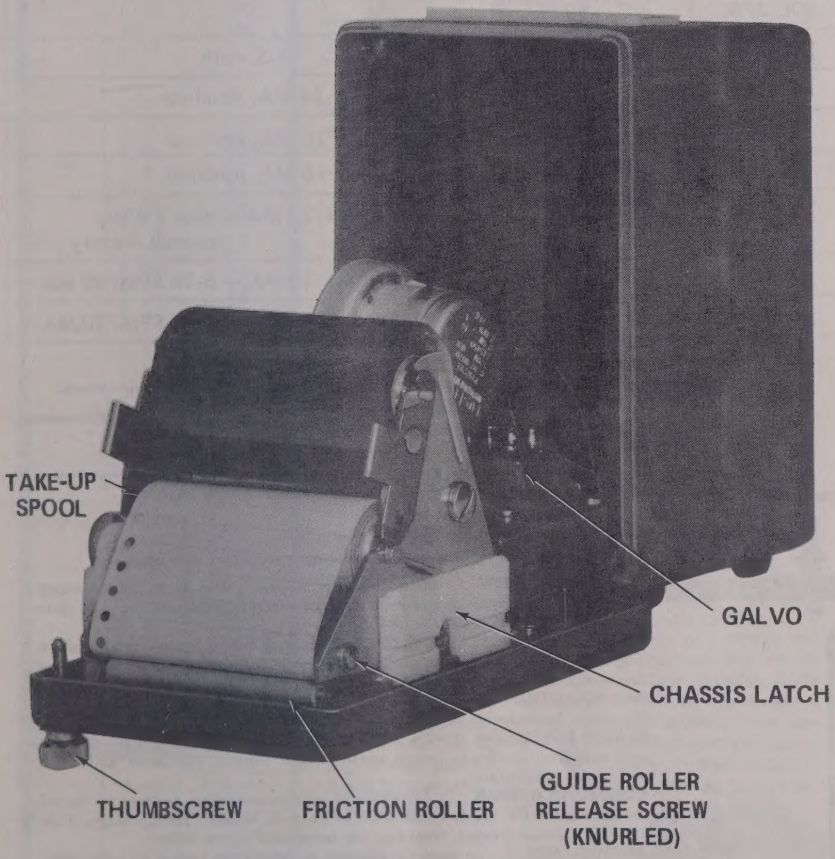


Controlling chart speed, and consequently, trace density, is a gear train mounted on the side plate. This reduction gear assembly couples the motor to the drive drum and the reroll spool.



The Rustrak recorder transforms angular motion of the galvanometer through the striker bar to obtain rectilinear recording.

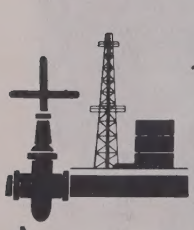

CARDHOLDER
MOTOR
TAB
SUPPLY ROLL
RETAINING CLIPS
GEAR TRAIN SPRING
GEAR TRAIN
QUICK REVIEW THUMBWHEEL
GUIDE ROLLER


TAKE-UP SPOOL
GALVO
CHASSIS LATCH
THUMBSCREW
FRICTION ROLLER
GUIDE ROLLER RELEASE SCREW (KNURLED)

DRIVE MOTOR SPECIFICATIONS

INPUT VOLTAGE	TYPE	AC POWER or DC CURRENT REQUIREMENTS
100-135	AC, 60 Hz.	5 watts
100-135	AC, 50 Hz.	
200-270	AC, 50 Hz.	
100-135	AC, 400 Hz.	6.5 watts
6	DC Unregulated†	24 MA, nominal
12		20 MA, nominal
24-28		10 MA, nominal
6	Solid-State Inverter/Motor‡ (DC input)	2 RPM or less: 25 MA — over 2 RPM, consult factory
12		4 RPM or less: 10 MA — 6-16 RPM: 60 MA
24		2 RPM or less: 10 MA — 4-16 RPM: 30 MA

†Speed regulation of unregulated DC motors is ±5% at rated voltage only.
‡Speed regulation of solid-state inverter/motors is ±0.5% over range of ±20% of rated voltage.



TYPICAL APPLICATIONS

here are just a few ways that Rustrak recorders are used —

OCEANOGRAPHY . . . in Bathyscaphs Trieste I and II to record water temperature, depth position of vehicle, water pressure, ocean current and state of charge of the main battery power

FISH MIGRATION . . . in a U. S. Department of Interior study to record the amplified signals transmitted to hydrophones by fish that have been captured and instrumented with sonic projectors

AIR POLLUTION . . . in government studies to record smoke density, continuously, by scanning with light source, photo cell and amplifier system

WATER POLLUTION (OPEN AND CLOSED SYSTEMS) . . . in government and industrial studies to record water oxygen content, pH factor and other significant parameters

COMMUNICATIONS . . . in telephone and broadcasting systems to record switchboard traffic loads versus time of day—to monitor plate voltage, plate current, antenna current, frequency deviation and power output

AGRICULTURE . . . in research projects to record the output of solar cells, intensity of sunlight penetration, soil, fruit and leaf temperatures, and many other parameters

METEOROLOGY . . . in government installations to record wind velocity and direction, and atmospheric potential gradients tending to produce lightning, especially in the vicinity of missile sites

FOOD PROCESSING . . . in the cheese industry to record temperatures . . . in the maple sugar industry to record temperature, volume and rate of flow . . . in both industries to provide analog and event data for operations control

TRANSPORTATION . . . in the trucking industry to record temperature, events (i.e., stop, go, elapsed time), air pressure and temperature in air-brake systems —in petroleum research, to measure the temperature of lubricants in crankcase, gear transmission and rear end transmission

MEDICAL . . . in hospitals and doctors' offices to record temperatures, blood pressure, heart and breathing rate

rustrak

DC RECORDERS

DC Recorders record DC parameters. Motor power, whether AC or DC, has no meaning in this classification. Standard Rustrak DC recorders are supplied with a 115 VAC, 60 Hz motor.

Model 288: The basic recorder of the Rustrak line uses a galvanometer movement with internal shunts and multipliers when needed. See *Table 1* for basic and extended ranges. Its construction complies exactly with the general description.

Power and meter connections are made to the recorder through a P 3306-08-AB chassis plug. A matching S 3306-08-CCT receptacle is furnished with each instrument.

Model 291: This DC recorder houses two galvanometers for recording any two separate parameters simultaneously on the same chart. Channels are independent of each other. See *Table 2*.

Connections to the Model 291 are made through a P 3306-08-AB chassis plug and matching receptacle. Always refer to the data tag inside the recorder for correct wiring information.

Accessories (for Models 288 and 291):

Model 881, External Shunt: External shunts are used when currents in excess of 5 amperes are to be recorded. Model 881 shunts are intended for use with our basic 0-1 ma. DC recorders only.

Each 100 millivolt shunt is made of manganin shunt strip for stability over a wide range of ambient temperatures. Maximum shunt temperature (self-heating) is less than 80°C. when operated for one hour at maximum current in an ambient of 25°C. Accuracy is ±0.25%.

Model 111A (&B) Multiranger: The Multiranger when used with a 0-1 ma. Model 288 or 291 recorder, allows the operator to select one of seven current or voltage ranges (fourteen total) with a front panel selector switch. A slide switch connects a multiplier string in series for voltage recording or parallels the meter across the shunt selected for current readings. The second slide switch, also mounted on front panel, is used as an on-off switch for the recorder motor. This on-off switch can be used only with recorders using AC driven motors. But, as shown in the Installation Chapter, the switch and lamp can be customer-rewired for DC power sources.

An "A" suffix multiranger offers scale multiplier factors of 1, 5, 10, 50, 100, 500 and 1000 volts or milliamperes. The "B" suffixed instrument furnishes factors of 3, 15, 30, 75, 150, 300 and 750.

Either model is supplied with a prewired cable for quick connections between the recorder, multiranger and to the lines.

Model 111A

TABLE 1

MODEL 288 RECORDER

Units	Range	Galvanometer Resistance in Ohms
μA	0 - 10†	5700
	0 - 50	5400
	0 - 100	4600 1000
	0 - 200	2200
	0 - 500	200
MA	0 - 1	100
	0 - 1.5	Uses basic 1 MA galvanometer with appropriate internal shunt
	0 - 3	
	0 - 5	
	0 - 10	
	0 - 15	
	0 - 30	
	0 - 50	
	0 - 75	
	0 - 100	
	0 - 150	
	0 - 300	
	0 - 500	
	0 - 750	
Amp.	0 - 1	
	0 - 3	
	0 - 5	
MV	0 - 10	10
	0 - 25	12.5
	0 - 100	100
V	0 - 1	Uses basic 1 MA galvanometer with appropriate internal multiplier. Sensitivity—1000 ohms/V. Other sensitivities to 100K ohms/V available to order.
	0 - 3	
	0 - 5	
	0 - 10	
	0 - 15	
	0 - 30	
	0 - 50	
	0 - 75	
	0 - 100	
	0 - 150	
	0 - 300	
	0 - 500	

TABLE 2

MODEL 291 RECORDER

Units	Range	Galvanometer Resistance in Ohms
μA	0 - 50	5400
	0 - 100	4600 1000
	0 - 500	100
MA	0 - 1	100
MV	0 - 50	100
	0 - 100	100

Galvanometer: Taut-band suspension
Response Time: 1.0 second (open circuit)
Maximum Writing Speed: 1 strike per second
Recommended Maximum Chart Speed: 24 inches / hour

AC RECORDERS

AC Recorders record alternating currents and voltages. Like DC recorders in the previous group, their classification depends on use, not on the internal drive motor. Therefore, an AC recorder may be driven by a DC motor.

The accuracy of these recorders is guaranteed at the calibration frequency (specified at time of purchase) only. Most AC recorders are frequency sensitive. Special notes on frequency calibration are found in the *Calibration Section.*

Model 288R: A single channel AC recorder, this model uses a DC D'Arsonval movement fed by a copper oxide bridge rectifier. Rear-mounted five-way binding posts connect to taps on the multiplier string and are labeled with the correct multiplier factor. See *Table 3* for ranges.

Model 293: This series of AC recorders features a suppressed galvanometer movement for high resolution readings of commercial line voltages. See *Table 3.* Accuracy is ±3%.

Model 2118: This alternating current recorder features two ranges of 0-1 and 0-5 amperes respectively. Rear-mounted binding posts are used for terminal connections.

A transducer converts the input current to an AC voltage fed across the full wave bridge rectifier. The rectifier load resistor, calibration control and meter filter are mounted in a metal can within the recorder case.

The Model 2118 is frequency sensitive and should be used at frequency of calibration only (specified at time of purchase.

Model 2107: Using clamp-on transducers, the Model 2107 checks line loads without breaking the circuit or interrupting machinery. A single channel recorder, it is equipped with a rear-mounted selector switch for instruments having up to three ranges. Two transducers are available (though not interchangeable): for readings up to 300 amps with the smaller and to 1000 amps with the larger.

Model 2120: This dual channel AC recorder records both current and voltage simultaneously. *Table 4* depicts its ranges.

Essentially it represents two recorders in one housing. The current range uses a standard galvanometer and transducer similar to Model 2118. Its voltage channel features a suppressed galvanometer movement for recording the more common commercial line voltage ranges.

Model 2186: Either instrument in this series offers high resolution ranges centered at nominal AC line voltages. It is zener regulated for an accuracy of 0.5% over the range of 10 to 40°C.

Model 2113: This instrument records up to 600 volts AC in 3 voltage ranges and alternating currents up to 150 amps in 4 ranges. Both current and voltage ranges can be selected with a concentric switch located on front panel.

TABLE 3

SINGLE CHANNEL RANGES

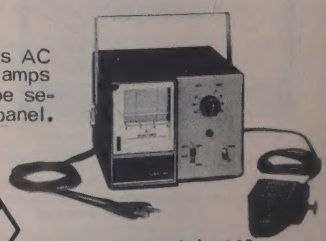
MODEL	RANGE	UNIT
288R (choose 1 to 3 ranges)	0 - 10 0 - 50 0 - 150 0 - 300 0 - 600	VOLTS
293 (1 range)	70 - 135	
293A (2 ranges)	70 - 135 140 - 270	
293B (3 ranges)	70 - 135 140 - 270 280 - 540	
2118 (2 ranges)	0 - 1 0 - 5	AMP
2107 w/small clamp-on transducer (choose 1 to 3 ranges)	0 - 10 0 - 20 0 - 30 0 - 50 0 - 100 0 - 200 0 - 300	Clamp-on for 1" Max. Cable Dia.
2107 w/large clamp-on transducer (choose 1 to 3 ranges)	0 - 100 0 - 200 0 - 300 0 - 400 0 - 500 0 - 600 0 - 700 0 - 750 0 - 800 0 - 1000	Clamp-on for 2" Max. Cable Dia.

TABLE 4

DUAL CHANNEL RANGES

MODEL	CHANNEL 1 AMPERES	CHANNEL 2 VOLTS
2120	0 - 5	100 - 140
2120A	0 - 5	100 - 140 200 - 280
2120B	0 - 5	100 - 140 200 - 280 400 - 560

By using the panel-mounted slide switch, the operator can record voltage or current, or both alternately. The Time Sharing Feature, F137, is built into this instrument for two-point recording over the entire chart width. For easy identification, the current trace is interrupted. The Model 2113 has clip leads for voltage measurements and a clamp-on transducer for current ranges. Because of the F137 feature, motor choice is limited to 1 rpm speed.



Model 2113

AC WATTS AND VARS RECORDERS

TABLE 5
WATTS & VARS RECORDERS

DASH NO.	INPUT 50/60 Hz AMP	INPUT 50/60 Hz VOLT	2164 2164V* 1-Phase	2164A 3-Phase 3-Wire Δ or Y	2164B 3-Phase 4-Wire Y
-1	.5	120	0-50	0-100	0-150
-2	1	120	0-100	0-200	0-300
-3	.5	240	0-100	0-200	0-300
-4	1	240	0-200	0-400	0-600
-5	5	120	0-500*	0-1000	0-1500
-6	10	120	0-1000*	0-2000	0-3000
-7	5	240	0-1000*	0-2000	0-3000
-8	10	240	0-2000*	0-4000	0-6000
-9	20	120	0-2000	0-4000	0-6000
-10	20	240	0-4000	0-8000	0-12000
No. of transducers			1	2	3

*Model 2164V available for -5, -6, -7, and -8 single phase only.

Model 2164 Series: Model 2164 single phase and Models 2164 A and B recorders measure and record true power in an AC circuit. A Hall effect transducer is used in the input. This transducer instantaneously computes real power and converts it to a DC voltage that is recorded against a WATT scale.

See *Table 5* for ranges.

This recorder is also manufactured, although in limited ranges, to record reactive power in vars. Model 2164V is limited to single phase operation and to 2000 vars, full-scale readings.

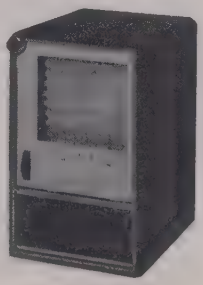
EVENT RECORDERS

Model 292 Series: Depending on model, these recorders register on-off data on four or eight independent channels using actuators (solenoids) to activate pens. No galvanometer is required.

Each pen presses against the chart paper, leaving a continuous trace. When an event (contact closure) occurs, the actuator (solenoid) snaps the pen to the right, forming a pulse .04" to .06" high. The trace is rectangular with pulse width dependent on duration of the event.

Six volt DC actuators draw 300 ma.; 150 ma. if 12 VDC; 70 ma. if 24 VDC or 35 ma. if 48 VDC. Be sure to read data tag inside your recorder for correct actuator voltage. Units ordered from stock usually have 24 VDC actuators.

Accessories such as the Model 921-8 Power unit and switching amplifiers are factory designed to complement the event recorder. See descriptions below.



Model 292-8

Model 2146: This recorder features one galvanometer channel similar to the Model 288 and one event channel like that on the 292. Chart width is divided between channels, allowing 2" for the analog channel and ¼" for the event marker.

Except for ranges and chart width, the descriptions of the Models 288 and 292 apply to the Model 2146.

Accessories for Event Recorders

Model 920 Switching Amplifier: Model 920 is a solid-state amplifier which amplifies low level AC pulses from low to medium impedance transducers to produce on-off DC pulses to activate the event actuator. It operates from 115 VAC, 60 Hz.

At full gain, the amplifier responds to signals of 10 millivolts minimum between 10 Hz and 10 KHz, producing an output of 24 VDC @ 100 ma. into a resistive load of 250 ohms ±40%. This tolerance in output resistance without degradation of current response allows a separation of up to 6000 feet (using #22 AWG pair) between units.

The output stage is normally biased to cutoff. Signals from the transducer, amplified by the first two stages, trigger the power output stage and cause it to conduct. A white panel lamp in series with the collector lead lights when this stage conducts, and the pen is actuated in the event recorder.

A delay circuit holds the actuator on to prevent chattering due to transients. This delay circuit may be adjusted from a no-delay condition to a maximum of 3 seconds delay with a front-panel screwdriver adjustment.

Model 922: This unit is a solid-state high-gain amplifier supplied with a photoelectric cell and light source. Useful for counting applications, the amplifier triggers the event recorder on light interruption. A white panel lamp also lights during interruption.

Units (event recorder and amplifier) may be located up to 2000 feet apart (using

#22 AWG pair). The photocell and light may be separated by up to 20 feet.

Models 921-8 and 921A-8: Power supplies which furnish actuator power to event recorders. Primary power is 120 VAC or 240 VAC (Model 921A-8) and output is 24 VDC @ 560 ma.

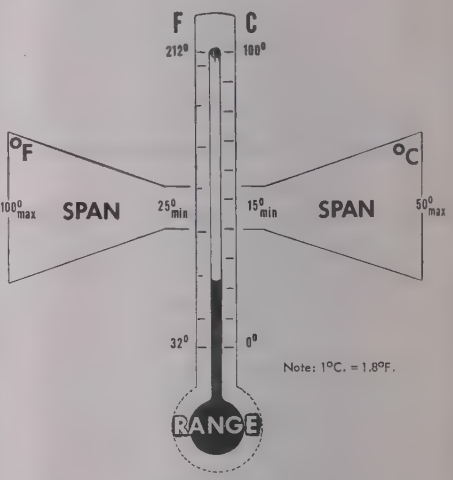
TEMPERATURE RECORDERS

Model 2122: This four-range recording pyrometer is a single channel instrument supplied with two thermocouples; one Iron/Constantan, the other Chromel/Alumel. Available in °F or °C calibration, it features a taut-band suspension movement. Maximum writing speed is one strike per second and recommended maximum chart speed is 24 inches per hour.

Model 2133: This series of temperature recorders feature high-resolution over narrow temperature spans. Four thermistor probes useful for varying applications can be interchanged without calibration or adjustment of the recorder.

Temperature range of this series of instruments is 0 to 100°C. (32 to 212°F.) with an accuracy of 2% of span selected within these limits. While special ranges are available and possible, accuracy is often affected. If your instrument has a special range, please check the tag inside your recorder for special information.

On this tag, you will also find notes on the temperature span of your recorder. In the standard instrument operating within the range of 0 to 100°C., the minimum span is 15°C. (25°F.) and the maximum span is 50°C. or 100°F.



Model 2144: This model recorder covers a wide range of temperatures with spans of 100°F. to 600°F. available on order. Using nickel wire as a sensing element the Model 2144 operates from -100°F. to 600°F. Featured accuracy over this range is ±2.5% of span and 0.5% of full scale temperature.

Essentially a bridge circuit, the recorder uses compensating resistors in the ratio arms to assure linearity over the span selected.

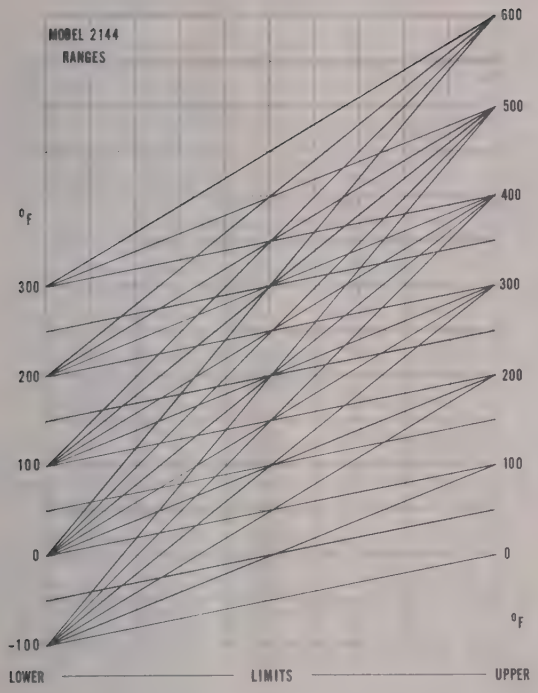
Two models are available: a single channel recorder using one probe and a single channel differential recorder with two probes. All probes are interchangeable without recalibration and are easily interchanged.

Model 2155: This instrument uses a Type "J" or Type "K" thermocouple without need for intermediate amplification. Like other temperature recorders in the Rustrak line, the Model 2155 is available in many ranges calibrated in °F. or °C. Please refer to the scale on your instrument for range and to the tag inside your recorder for special information.

Thermocouple probes for use with these recorders are sold separately and are not interchangeable. Each type is housed in a 3/16" OD stainless steel sheath, 6" long and terminated with a 6 foot armored cable. A pressure fitting may be used with these probes.

Model 2166: This self-contained temperature recorder covers the range of -50° to +100°C. using a nickel wire sensing probe supplied with the instrument. It is designed for use as an environmental monitor and requires only a source of AC power for operation. The recorder has an on-off switch on the rear panel and a push button switch to check calibration.

The probe is housed in a stainless steel sheath 3/16" OD by 4½" long with a ten-foot vinyl covered cable.



Select Lower Limit. Use straight edge to find Upper Limit.

PRESSURE RECORDER

Model 2162: This pressure recorder uses a C-type Bourdon tube with a direct coupled pointer for recording pressure of gases and liquids. Single channel, it is furnished with any one of several standard ranges. Please check your scale for range and the plate inside your recorder for special information. An adapter permits plumbing interchange of the Model 2162 with most panel pressure gages. Vacuum ranges or combination vacuum-pressure ranges are available on special order. The smallest span available is 15 psi. Maximum pressure is limited to 500 psi.

Model 2194: This recorder has a full-scale sensitivity of 1 microampere to provide a range of 0 to 10 millivolts DC with an input impedance of 10,000 ohms. Using solid state circuitry, no external amplification is needed.

Because of its high sensitivity, this recorder can be used with temperature bridges, strain gage bridges or as a highly sensitive recorder accessory for laboratory instruments.

Usually AC operated, this recorder may be ordered for battery operation, drawing 30 ma. at 12 volts DC. Refer to the inside tag of your recorder for this information.

The accuracy of this recorder is ±2% FS including temperature effects and features a response time of one second.

rustrak RECORDER FEATURES

Command Print: For all models except event recorder series.

F109A: Recorders equipped with the Selective Command Print Feature, F109A, don't have a cam-operated striker bar. Instead, the striker bar is actuated by a solenoid. If your recorder is so fitted, it will not record until the solenoid is energized. The striker bar presses against the galvanometer stylus as long as the solenoid is activated. Average duty cycle must not exceed 25%. Connections to the solenoid are made through pins 5 & 6 of the rear-mounted chassis plug in the 288 single channel DC recorder. In other models, the solenoid terminates at two yellow binding posts on the rear panel. Check inside label for correct wiring terminals and solenoid voltages. Operating voltage is printed directly on rear case for models using binding posts.

F109B: This feature, unlike the F109A, uses the motor cam to actuate the striker bar, but the motor cam doesn't engage until the solenoid is activated. As long as the solenoid is energized, the recorder operates normally. It will stop printing as soon as solenoid power is interrupted. Duty cycle of this solenoid may be up to 100%. Refer to F109A feature above for solenoid connections

Specials: Other Command Print arrangements are possible. Recorders so equipped come with a special data sheet and technical description.

Quiet Feature: For all models except event recorders.

F1: No special user information is needed for recorders so equipped. This feature reduces impact noise but represents a trade-off between operating speeds and striker bar noise. Selection of chart and writing speeds is shown below:

Strikes/15 sec.	Motor rpm	CHART SPEED IN INCHES PER HOUR							
1	1/2	1/32	1/16	1/8	1/4	1/2	3/4	1	1-1/2
2	1	1/16	1/8	1/4	1/2	1	1-1/2	2	3
4	2	1/8	1/4	1/2	1	2	3	4	6
8	4	1/4	1/2	1	2	4	6	8	12
12	6	3/8	3/4	1-1/2	3	6	9	12	18
16	8	1/2	1	2	4	8	12	16	24
GEAR TRAIN ASSEMBLY #		*1/8*	*1/4*	*1/2*	*1*	*2*	*3*	*4*	*6*

Two Point Feature:

F137: Recorders equipped with this feature can print two traces on the same chart while using only one galvanometer. Inputs are switched with a motor cam to produce two independent traces identifiable by a break that occurs each half inch on one trace. With this feature, a single channel recorder can monitor two signals while a dual channel instrument becomes a four point recorder.

For single channel recorders using the chassis plug, the second channel, the interrupted trace called Point #2 in our catalog, is wired to pins 5 & 6. The solid trace signal is fed as usual to pins 1 & 2. All other recorder models including dual channel recorders use binding posts mounted on the rear case panel. Identifying marks and other data are printed near each of these binding posts.

Certain limitations in chart and writing speed are inherent with this feature.

Strikes per sec.	Motor rpm	CHART SPEED IN INCHES PER HOUR									
1 per 8 sec.	1/2	1/32	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2-1/2	3
1 per 4 sec.	1	1/16	1/8	1/4	1/2	1	1-1/2	2	3	5	6
GEAR TRAIN ASSEMBLY #		*1/8*	*1/4*	*1/2*	*1*	*2*	*3*	*4*	*6*	*10*	*12*

Controller:

F204: The Model F204 Controller is an on-off type capable of controlling up to 5 ampere resistive loads.

Choice of A or B configuration is dictated by the equipment to be controlled.

STYLE A Controller closes the relay contacts below the set point and opens them above. This style is ideal for temperature control because of its fail-safe characteristic. If power fails, the relay de-energizes, disconnecting the load. A fail-safe alarm can be wired to the normally closed contacts. When the relay de-energizes, the alarm will be connected.

STYLE AA (two set points) could be arranged so that temperature control is achieved at one point. In this case, the second set point is adjusted above the first and wired so that the entire system shuts down if exceeded. Adding the alarm would give a warning when this happens. Style AA with the output relays appropriately interconnected could provide a simple logic that can divide the scale into three segments for sorting or grading.

STYLE B Controller closes relay contacts above the set point and opens them below. This style is suited for refrigeration control.

STYLE AB Controller can be used to provide go-no-go or low, in, high information for grading and sorting.

Set point resolution for the standard controller is 0.25 millivolts

INSTALLATION INSTRUCTIONS

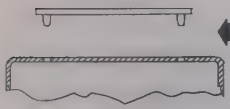
MECHANICAL:

Your recorder comes with hardware for portable use and for panel mounting. Each of these items is included in the hardware kit. None is affixed to the recorder when shipped. A kit consists of:

- 4 - Rubber feet
- 1 - White Plastic Cardholder
- 2 - Aluminum Brackets
- 4 - 4-40 x ¼" Screws
- 2 - 8-32 x 5/16" Panhead Screws
- 2 - 8-32 x ¼" Panhead Screws
- 2 - Speed Nuts

Portable Operation

For portable operation, install rubber feet in tapped holes at bottom of case using four (4) 4-40 x ¼" screws provided.



Snap white plastic cardholder into two holes at top.

Panel Mounting

For panel mounting, don't install rubber feet or cardholder. Referring to *Figure 1*, mount bottom bracket to recorder case using two (2) 8-32 x ¼" Panhead screws. Similarly, affix top bracket using two (2) 8-32 x 5/16" Panhead screws and speed nuts furnished. Mount top brackets in holes used for cardholder. Be sure to use shorter screws in bottom to prevent jamming recorder mechanism. When

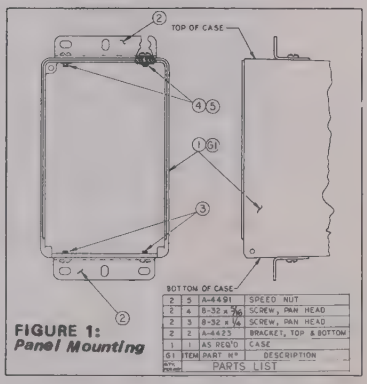

TOP OF CASE
BOTTOM OF CASE
2 5 A-4491 SPEED NUT
2 4 8-32 x 5/16 SCREW, PAN HEAD
2 3 8-32 x ¼ SCREW, PAN HEAD
2 2 A-4423 BRACKET, TOP & BOTTOM
1 1 AS REQ'D CASE
ITEM PART Nº DESCRIPTION
PARTS LIST

FIGURE 1: *Panel Mounting*

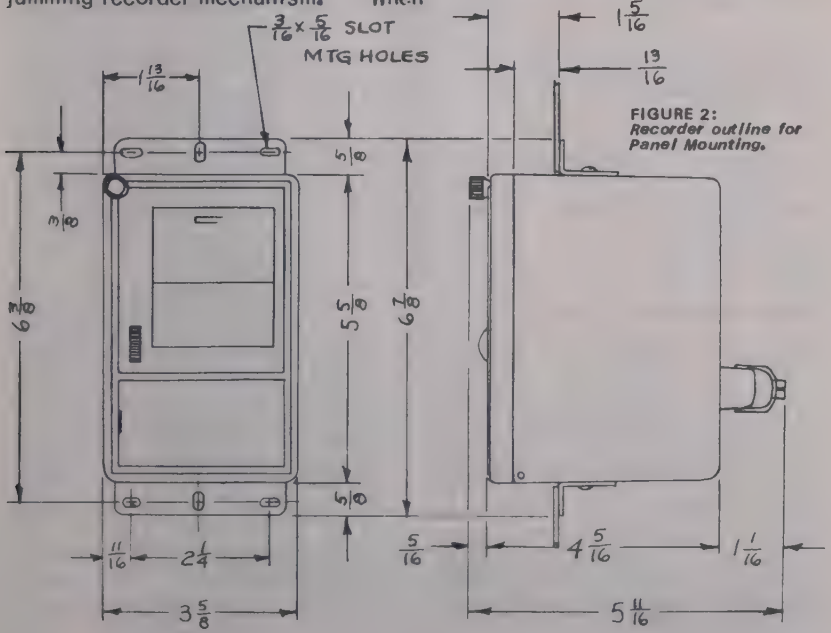


FIGURE 2: *Recorder outline for Panel Mounting.*

so equipped, the recorder fits into the cutouts of Model 176 relay rack panels. Mount the recorder with 6-32 hex nuts and lockwashers. (6-32 studs are factory mounted).

For mounting recorders in custom designed panels, refer to *Figure 2*. These dimensions apply to all recorders discussed in this manual.

ELECTRICAL: WIRING TO AND FROM YOUR RECORDER

Terminal connections are printed on a label affixed to the inside case of your recorder. Such information is normally sufficient for correct wiring.

A matching socket is shipped with all recorders using the P-3306-08-AB six prong Jones chassis plug. Terminal connections are:

TABLE 1: TERMINAL CONNECTIONS

Pin #	DC Single Channel	DC Dual Channel	AC Recorders
PIN 1	GALVANOMETER +	GALVANOMETER +	COMMON
PIN 2	GALVANOMETER −	GALVANOMETER −	FIRST RANGE *2
PIN 3	MOTOR +	MOTOR *1	MOTOR *1
PIN 4	MOTOR −	MOTOR *1	MOTOR *1
PIN 5	GROUND *4 *3	GALVANOMETER +	SECOND RANGE *2
PIN 6	*3	GALVANOMETER −	SECOND RANGE *2

* Note 1: DC motors are polarized. The positive terminal is always Pin 3. AC operated motors have no polarity.
* Note 2: Multi-range recorders, both AC and DC, use Pins 5 and 6 for additional ranges.
* Note 3: Model 2146: Event marker actuator is wired to Pins 5 and 6.
* Note 4: When all pins are used and the instrument must be grounded, attach a solder lug to the screw holding the chassis plug.

TABLE 2: TERMINALS USED ON RECORDERS (BY MODELS)

Model	Standard Terminals	Notes	Motor Connections
288	P-3306-08-AB chassis plug	Ranges 300v. and above use binding posts	Pins 3 & 4 of chassis plug
291	P-3306-08-AB chassis plug	Binding posts above 300v.	Pins 3 & 4 of chassis plug
288R	P-3306-08-AB chassis plug	Binding posts 150v. and above; combination on multi-ranges	Pins 3 & 4 of chassis plug
293	P-3306-08-AB single range; Binding posts on suffix A & B	Chassis plug used in combination with posts	Pins 3 & 4 of chassis plug
2118	Three binding posts labeled AC Amps on rear	One common, 1A & 5A	Three conductor grounding line cord (AC) Blank end cord for DC motors
2107	Transducer uses quick-disconnect to furnished cable.	Range switch on rear for multi-range instruments.	Grounding line cord for AC Blank end cord for DC
2120	Binding posts for both current and voltage	Separate common for current and voltage	Permanently affixed line cord as for Model 2107
2113	Transducer permanently attached	Standard item with no deviations	Permanently affixed line cord as for Model 2107
2164	Barrier strips	See special instructions	Line cord permanently affixed
292	Barrier strips	See section on event recorders	Grounding line cord for AC Blank end cord for DC
2146	P-3306-08-AB chassis plug	Pins 5 & 6 for event marker	Pins 3 & 4 of chassis plug
2122	Color-keyed binding posts	Range switch, on-off switch and cal. button in rear	Grounding AC line cord or blank end DC cord
2133	Telephone jacks; one, two or three depending on suffix	Standard phone plug probe termination	Grounding AC line cord or blank end DC cord
2144	One or two telephone jacks depending on ranges	Probes come equipped with phone plugs	Grounding AC line cord or blank end DC cord
2155	Color-keyed binding posts	Probes have spade lugs	Grounding AC line cord or blank end DC cord
2166	Phone jack	Probe has phone plug	Grounding AC line cord or blank end DC cord
2162	1/8" Male NPT fitting	Uses no galvanometer	Grounding AC line cord or blank end DC cord
2186	Binding posts, four on reg. models, six on suffix A	Two binding posts per range, no common	Grounding AC line cord or blank end DC cord
2194	Two binding posts, black and red		Grounding AC line cord or blank end DC cord

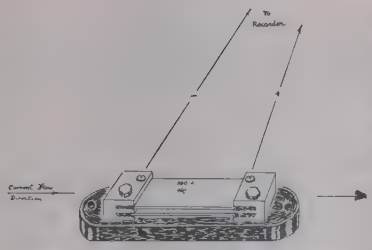


FIGURE 3. *Model 881 Shunt. Wiring polarity (based on direction of current flow) should be observed when connecting shunt to recorder.*

DC Accessories:

Model 881 Shunts (see *figure 3*): Copper or brass end blocks on Rustrak Model 881 shunts have separate current and recorder terminals to avoid errors due to the parasitic resistance of the wire-to-shunt connection.

Adequate conductors tightly fastened, clean contact surfaces and free air circulation are important.

Connections to the recorder should be made with wire equal to or larger than #18 gauge. USA Standard C39.1 specifies that standard lead resistance is 0.065 ohms, equivalent to a five foot long pair of .040" OD (#18 B&S) copper wire. Your Model 881 100 mv. shunt is calibrated in accordance with that standard.

Multiranger: Models 111A & B Multirangers come equipped with a cable for use with a Model 288 0-1 ma. recorder. However, the schematic and wiring connections are included for conversion or for use in other applications. A standard Jones plug is used for terminals and the mating plug is available from most electronic jobbers.

Please note motor connections (pins 3 & 4) are wired in series with S1, the on-off switch, to the AC line using terminals 4 and 6 on J1, and in parallel with I1, the panel lamp. If the multiranger is wired to recorders using DC motors, modify wiring to J1 as shown in *Table 3*.

FIGURE 4: *Type A&B Multiranger Schematic*

– A	NO.	– B
900 Ω	R1	2.9 K
4.02K	R2	12.1K
4.9K	R3	15K
40.2K	R4	45K
49.9K	R5	75K
400K	R6	150K
500K	R7	450K
NONE	R8	49.9 Ω
24.9 Ω	R9	7.14 Ω
10.0 Ω	R10	3.44 Ω
2.03 Ω	R11	1.34 Ω
1.00 Ω	R12	0.66 Ω
0.5 Ω	R13	.325 Ω
0.09 Ω	R14	.124 Ω

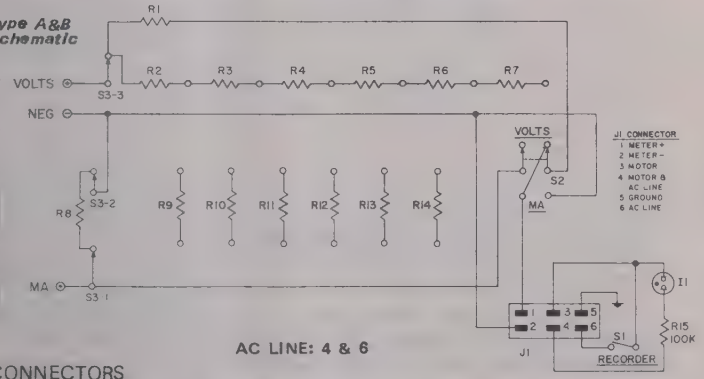


TABLE 3: J1 CONNECTORS

AC MOTORS	*DC MOTORS*
1 METER+	1 METER+
2 METER–	2 METER–
3 MOTOR	3 MOTOR+
4 MOTOR & AC LINE	*4 MOTOR– AND DC SOURCE–
5 GROUND	5 GROUND
6 AC LINE	*6 DC SOURCE+

** Panel lamp is inoperative with DC voltages normally used for recorder motors.*

Model 2164: The Rustrak Model 2164 instrument series record Power using a Hall generator as transducer. Basically, the arrangement of current and potential coils in the Hall generator watt transducer is similar to the normal construction of a standard single phase, a three phase wire or a three phase four wire wattmeter. But instead of developing torque to drive a pointer, the electromagnetic fields interact across the Hall crystal to develop a voltage which is directly proportional to the power input. The output of the crystal, 1 ma. maximum into a 100 ohm load, moves the

galvanometer pointer.

Single phase circuits: In a single phase circuit, power is equal to the product of voltage and in-phase current.

$$W = E_p I_p \cos \theta$$

where θ is the phase angle between the current and the voltage. Since W in a dynamometer equals torque, and W through the transducer yields voltage, the voltage output of the Hall generator watt transducer equals $E_p I_p \cos \theta$.

Wiring: The fixed field coils in a single element dynamometer carry the full load current to produce a field proportional to the load current. A resistor is used in series with the moving coil so that its field is proportional to the line voltage. Torque then equals **EI cos θ** equals active power. See *Figure 5* for equivalent circuit.

Models 2164-1 to 2164-10 are wired similarly and a pictorial diagram is shown in *Figure 6*. Be sure to connect jumper as illustrated.

Varmeter: Referring to *Figure 5*, if the moving coil resistor (Rm) of the dynamometer is replaced by a reactor, the moving coil current shifts 90° with respect to line voltage. The instrument then reads "imaginary power" expressed in volt-amps reactive or **vars**. Torque is **EI sin θ**.

This is the basis of the Rustrak Model 2164V Recording Varmeter. Connections are shown in *Figure 6*. The voltage output of the Hall generator watt transducer in this case is equal to **EI sin θ**.

Please note catalog limitations in vars ranges. Use wire size capable of handling maximum true power, adding a safety factor for reactive power.

Polyphase circuits: Model 2164A Three phase, three wire, Delta or Y load. True power in any polyphase system is indicated by one less wattmeter than the number of wires. Any dynamometer then requires a two element mechanism for reading true power in a three wire application. A typical wiring arrangement using a two element dynamometer is shown in *Figure 7*.

Similarly, Rustrak Model 2164A Watt

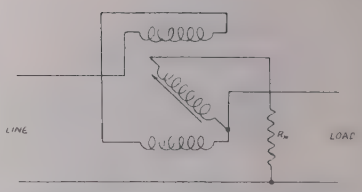


FIGURE 5. *Usual internal connections for single-phase load using single element dynamometer. (Analogous to Model 2164-1 to 2164-10)*

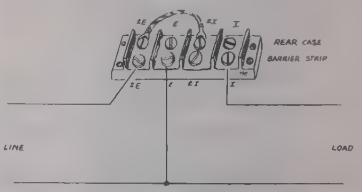


FIGURE 6. *Pictorial wiring diagram for Model 2164-1 to 2164-10. Be certain jumper is connected from ±E to ±I. Same wiring applies to Models 2164V-5 to 2164V-8.*

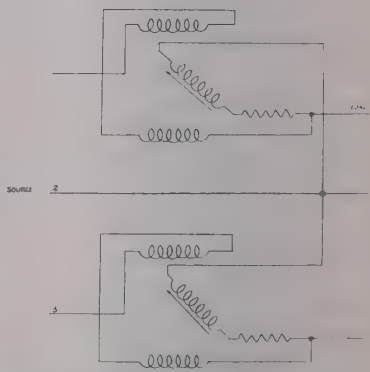


FIGURE 7. *Typical wiring arrangement for three phase, three wire, Delta or Y load using two element mechanism.*

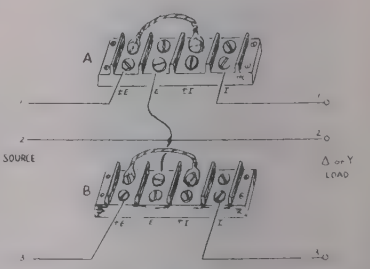


FIGURE 8. *Wiring pictorial for Models 2164A-1 to 2164A-10 for three wire, three phase wattmeter with Delta or Y load.*

recorders use dual elements wired in conjunction. *Figure 8* depicts required wiring at rear of recorder. Be sure to use wire size heavy enough to carry full line current.

Model 2164B: A three phase, four wire system requires a three element wattmeter for indicating true power. However, in practice, dynamometers use the 2½ element instrument which reads correctly if the voltages are undistorted and in balance though the currents be unbalanced. Current in one line actually passes through two elements but is displaced in phase by 60°. The component in phase with the moving coil current is half its actual value and the summation of the two elements gives the correct results.

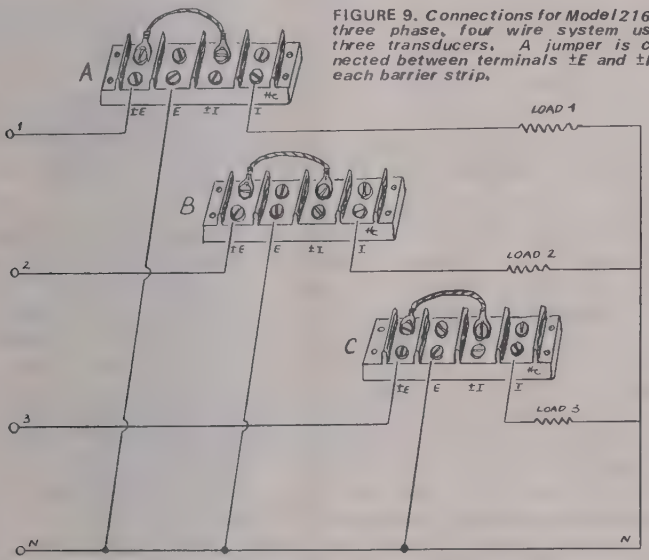


FIGURE 9. *Connections for Model 2164B, three phase, four wire system using three transducers. A jumper is connected between terminals ±E and ±I on each barrier strip.*

The Rustrak Model 2164B uses the three wattmeter method or three Hall generator watt transducers with outputs adding. Wiring follows the same method shown previously for other **watt** and **vars** recorders in this series and is depicted in *Figure 9*. Be sure to connect a jumper between ±E and ±I on each barrier strip.

Overload Ratings: Current overload on each transducer is twice rated current. If danger of momentary load shorting is possible, insert a quick blow fuse in series with each load or in place of the jumper between ±E and ±I terminals on each barrier strip.

Voltage across "E" terminals should not exceed 1.5 times rated voltage.

Event Recorders: Models 292-4 and 292-8

Rustrak event recorders, whether four or eight channel, operate on the same principle and use similar wiring. They are useful for recording on-off data from any system, machine or process in which a change of condition can actuate a SPST switch. *Figure 10* shows the basic wiring to be used for any (or either) channel.

Terminal markings on event recorders vary depending on model. The four channel recorder, Model 292-4, uses a single barrier strip with

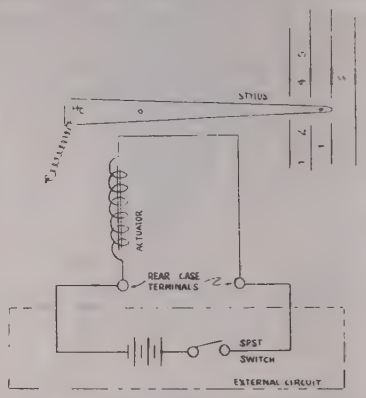


FIGURE 10. *Basic wiring to a Rustrak Event Recorder. A power source and SPST switch is needed to actuate each channel.*

FIGURE 11. *Model 292-4 terminal connections. Two terminals under each bracket designate channel number shown on chart paper. Screws and solder lugs are packed with recorders.*

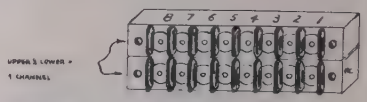


FIGURE 11A. *Model 292-8 terminal connections. Numbering designates channels as they appear on chart. Terminals are in line (upper and lower) under each channel number. Note Chinese numbering, i.e., from right to left to conform with chart face.*

channel markings shown in brackets above the strip. However, the eight channel event recorder uses two barrier strips with channel markings printed on the bakelite body. These markings (1 to 8) are **channel connections** and not strip numbering. Please refer to *Figures 11* and *11A* for connection pictorial. Each recorder is furnished with screws for the terminal strip and an equal number of solder lugs.

Actuators used in Rustrak event recorders are usually rated 24 VDC @ 70 ma. Other voltages are available at time of purchase. Before installing your event recorder, check the label inside the instrument for voltage rating. *Table 4* lists standard voltages and current needs. In case inside label is missing and voltage rating is unknown, refer to this table for approximate resistance values.

TABLE 4: ACTUATOR SPECIFICATIONS

		Single Channel	Model 292-4	Model 292-8
VOLTAGE RATING	APPROXIMATE RESISTANCE	CURRENT DRAIN PER ACTUATOR	TOTAL CURRENT FOUR CHANNELS	TOTAL CURRENT EIGHT CHANNELS
6V.	20 ohms	300 ma.	1.2A	2.4A
12V.	80 ohms	150 ma.	600 ma.	1.2A
24V.*	350 ohms	70 ma.	280 ma.	560 ma.
48V.	1.3 K	35 ma.	140 ma.	280 ma.

*24V. furnished as standard. Model 921 Power Unit can be used with this recorder.

Accessories for Event Recorders:

Power (Model 921) Units: These small power supplies furnish a well-regulated direct current for actuators rated at 24 VDC. Available in two models (921A-8 and 921-8), they are companion units to Models 292-4 and 292-8 event recorders. Each unit is housed in a standard electrical switch box with output terminals mounted on the plate. Since these power units are two terminal devices meant to replace a battery, they may be wired to an event recorder using zip cord or bellwire with a minimum rating of 50 VDC.

Switching Accessories:

Model 920 Switching Amplifier: This amplifier matches the 292 series event recorders and uses a similar barrier strip on its rear case panel. Refer to *Figure 12* for connection pictorial. Only the left four terminals

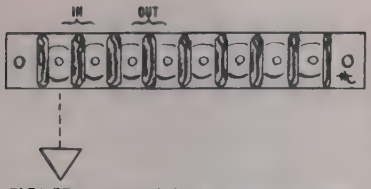


FIGURE 12. *Model 920 Amplifier connections. Far left input terminal is always ground. Output terminals provide 24VDC at 100 Ma. into actuator load.*

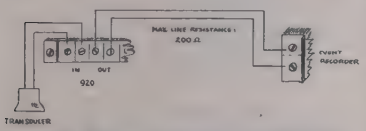


FIGURE 12A. *Typical connections to Model 920 Amplifier and 292 Event recorder. Switching amplifier and recorder can be connected with up to 6000 feet of number 22 pair.*

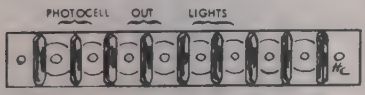


FIGURE 13. *Model 922 Photocell Amplifier connections. Output terminals provide 24VDC at 100Ma. into actuator load on light interruption.*

are used in this amplifier.

Figure 12A depicts a typical hookup using a 292 event recorder, a Model 920 switching amplifier and a transducer. The amplifier and event recorder can be physically remote from each other providing 200 ohm series loop resistance is not exceeded. This is the equivalent of 6000 feet of #22 twisted pair.

Model 922 Photocell Amplifier: Four units must be interconnected before operating: the event recorder, the photocell amplifier, the photocell and the lamp. Refer to *Figure 13* for terminal identification on the Model 922 Amplifier and to *Figures 11* and *11A* for event recorder connections.

Run two leads from the output terminals of the 922 Amplifier to the input terminals of one event channel. Polarity is unimportant. Zip cord or bell wire may be used providing total lead resistance doesn't exceed 70 ohms. This is the equivalent of 2000 feet, #22 twisted pair.

The photocell is terminated with two leads, six inches long, stripped and thinned. Splice two wires to these leads and connect to the terminals marked "Photocell" on the 922 Amplifier. The photocell may be located wherever convenient but, generally speaking, as close as practical to the amplifier.

Similarly, the lamp is terminated with two stripped and thinned leads. Connect these leads to the terminals marked "Lights" on the 922 rear case terminal strip. This lamp may be located up to 20 feet from the photocell but must be aimed to strike the light sensitive cell.

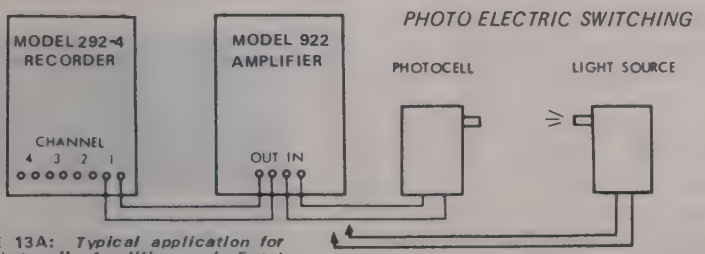


FIGURE 13A: *Typical application for 922 Photocell Amplifier and Event Recorder. Recorder registers each time light beam is interrupted.*

Special Recorders: Your instrument may be specially built or tailored to your application. Some combinations are temperature recording on one channel and current on the other, or current on the first channel and voltage on the second.

Refer to installation instructions for each specific type and wire as though you were using single recorders for each range or channel.

Applications: Other applications for event recorders and related accessories are shown in *Figure 14*.

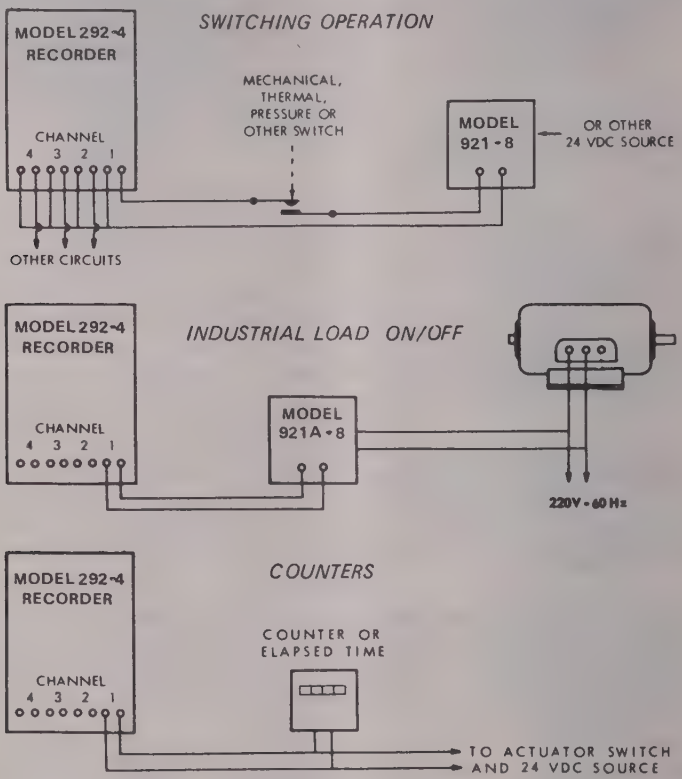


FIGURE 14: *Typical Applications.*

F204 Controller: This unit compares galvanometer voltage with a known reference voltage adjustable with control knobs. To install your Recorder/Controller, first wire the recorder portion of your instrument as shown in this chapter.

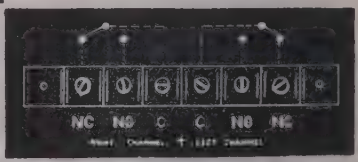


FIGURE 15. *Connections to F204 Controller. Each channel has three terminals to SPDT relay contacts rated at 5 Amps, resistive load. The left channel is controlled by the left-hand knob and rear connections are in-line with front panel directions.*

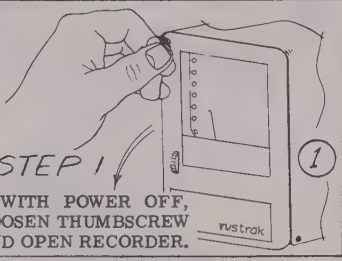
Then, referring to *Figure 15*, connect the controller contacts to the circuit to be controlled. Remember that the maximum resistive load safely handled by the controller contacts is 5 amperes, each channel.

Right and left channel designatives describe the location of the control knobs on the front panel. The controller type letters also designate location: the first letter refers to the left-hand control; the second letter designates the right-hand control. Rear panel connections are in-line with front panel directions.

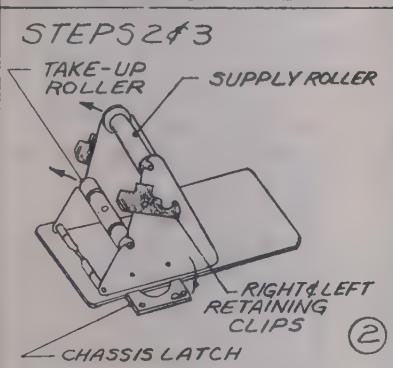
CHART LOADING INSTRUCTIONS

REROLL

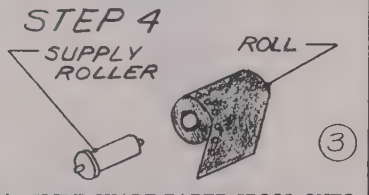
USES CARDBOARD SLEEVE, NOT BELTS.



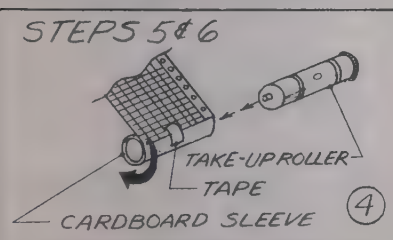
1. WITH POWER OFF, LOOSEN THUMBSCREW AND OPEN RECORDER.



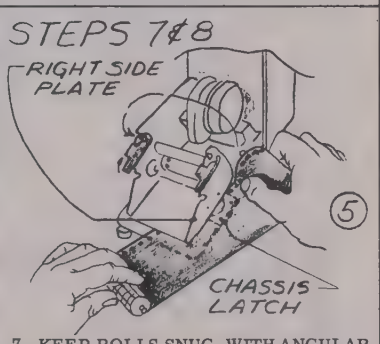
2. UNLATCH RETAINING CLIPS, OPEN CHASSIS LATCH. 3. REMOVE BOTH SUPPLY AND TAKE-UP ROLLERS.



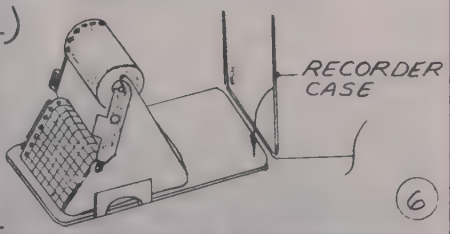
4. SLIDE CHART PAPER SPOOL ONTO SUPPLY ROLLER, PERFORATED EDGE OF PAPER BUTTS ROLLER SHOULDER. (SAVE GUMMED TAPE FOR STEP 6)



5. SLIDE EMPTY SLEEVE ON ROLLER. 6. TAPE PAPER TO SLEEVE, MAKING SURE PAPER IS PROPERLY ALIGNED. ROLL UP A FEW TURNS, GRAPH SIDE FACING UP.



7. KEEP ROLLS SNUG, WITH ANGULAR MOTION SLIDE PAPER LOOP (PERFORATED EDGE FIRST, BACK SIDE UP) INTO SLOT BETWEEN SIDE PLATE AND LATCH. 8. CAREFULLY ENGAGE SPROCKETS OF DRIVE DRUM WITH PAPER PERFORATIONS. INSERT SUPPLY ROLLER INTO TOP NOTCHES.

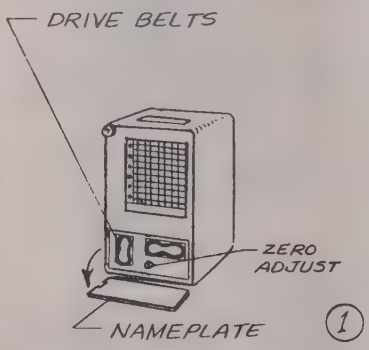


9. KEEPING PAPER TAUT, BRING TAKE-UP ROLLER INTO POSITION AND DROP INTO DEEPER NOTCH, ENGAGING GEAR. CHECK PAPER PERFORATIONS AND SEATING OF ROLLER. 10. LOCK RETAINING CLIPS AND SNAP CHASSIS LATCH INTO SIDE PLATE.

CLOSE RECORDER. ADVANCE PAPER AND SET TIME BY DEPRESSING AND TURNING CHART ADVANCE WHEEL.

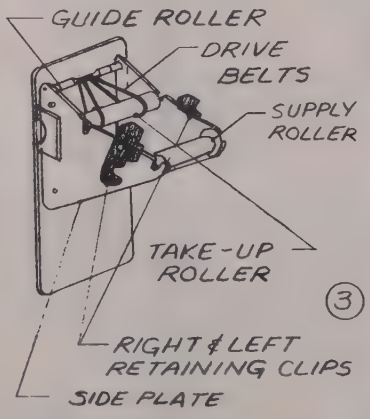
* SAVE CARDBOARD SLEEVE FOR REROLL MODE USE.

STEPS 1 & 2



1. SNAP OUT NAMEPLATE PANEL USING FINE SCREWDRIVER. REMOVE DRIVE BELTS AND REPLACE NAMEPLATE. 2. OPEN RECORDER BY LOOSENING KNURLED THUMBSCREW.

STEPS 5, 6 & 7



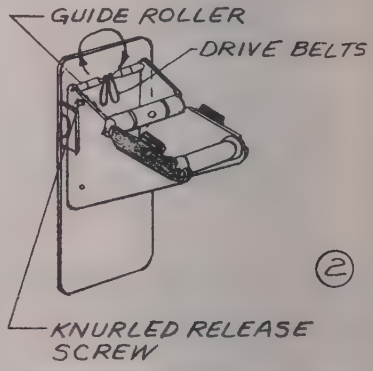
5. UNLATCH RETAINING CLIPS, REMOVE TAKE-UP ROLLER. MAKE SURE CARDBOARD SLEEVE IS OFF ROLLER. 6. PASS ROLLER THRU BELTS, SEAT ROLLER IN PLATES. ROLLER GEAR MUST ENGAGE IDLER GEAR; SEAT IN DEEPER NOTCH OF LEFT SIDE PLATE. 7. PULL DRIVE BELTS INTO LARGE CHAMFERED GROOVE OF GUIDE ROLLER & 'V' SLOTS ON TAKE-UP ROLLER.

AN ALTERNATE MODE OF OPERATION

TEAR-OFF *

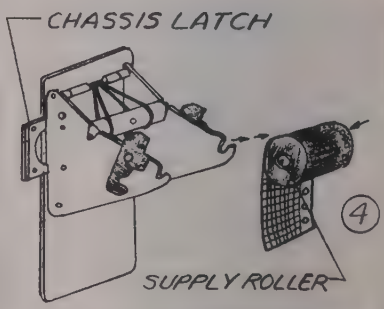
USES DRIVE BELTS, NOT CARDBOARD SLEEVE.

STEPS 3 & 4



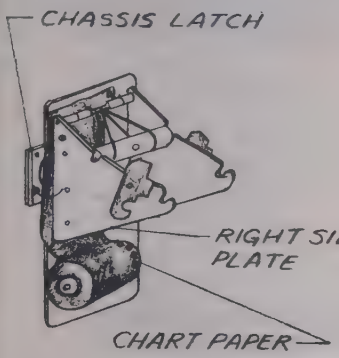
3. UNSCREW RELEASE SCREW TWO OR THREE TURNS. SPRING SIDE PLATE, REMOVE GUIDE ROLLER. 4. SLIP ROLLER THROUGH BELTS, REINSERT ROLLER INTO SIDE PLATE. FINGER TIGHTEN RELEASE SCREW.

STEP 8



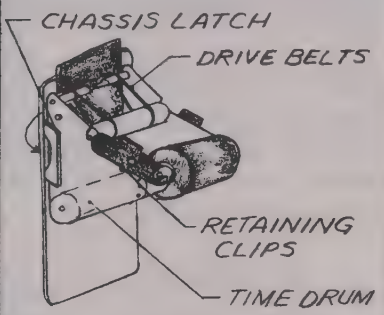
8. OPEN LATCH. REMOVE ROLLER AND INSERT INTO SPOOL OF CHART PAPER. PERFORATED EDGE OF PAPER MUST BUTT ROLLER SHOULDER.

STEP 9



9. UNROLL ABOUT SIX INCHES OF PAPER. WITH AN ANGULAR MOTION, SLIDE PAPER (PERFORATED EDGE FIRST, BACK SIDE UP) INTO SLOT BETWEEN THE RIGHT SIDE PLATE AND CHASSIS LATCH.

(FINAL)
STEPS 10, 11 12 & 13



10. SEAT SUPPLY ROLL IN NOTCHES PROVIDED, CLOSE RETAINING CLIPS. 11. CAREFULLY ENGAGE CHART PAPER PERFORATIONS WITH SPROCKETS ON TIME DRUM. 12. SNAP LATCH INTO SIDE PLATE. 13. WITH CHART PAPER UNDER GUIDE ROLLER, PULL BOTH DRIVE BELTS INTO SMALL 'V' SLOTS ON GUIDE ROLLER.

CLOSE RECORDER, TIGHTEN THUMBSCREW. WITH POWER APPLIED, RECORDER IS READY FOR TEAR-OFF OPERATION. ADVANCE PAPER AND SET TIME BY DEPRESSING AND TURNING CHART ADVANCE WHEEL.

CONVERSION INFORMATION

REROLL TO TEAR-OFF

USES DRIVE BELTS.

1. OPEN RECORDER. DROP CHASSIS LATCH.
2. UNLATCH BOTH RETAINING CLIPS.
3. REMOVE SUPPLY ROLL AND TAKE-UP ROLL. CLEAR THEM.
4. FIND DRIVE BELTS IN WELLS UNDER FRONT NAMEPLATE.
5. REMOVE CARDBOARD SLEEVE FROM TAKE-UP ROLLER.
6. PROCEED WITH STEP 3 IN TEAR-OFF LOADING INSTRUCTIONS.

TEAR-OFF TO REROLL

USES CARDBOARD SLEEVE.

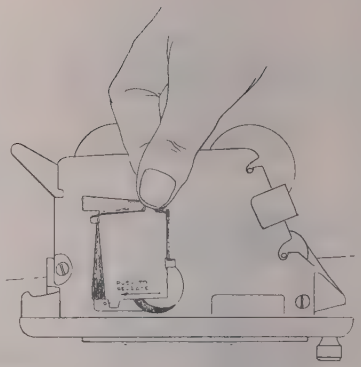
1. OPEN RECORDER. DROP CHASSIS LATCH.
2. UNLATCH BOTH RETAINING CLIPS.
3. REMOVE SUPPLY ROLL AND CLEAR ROLLER.
4. SLIP OUT TAKE-UP ROLLER FROM WITHIN DRIVE BELTS.
5. UNSCREW KNURLED RELEASE SCREW, SWING OUT GUIDE ROLLER AND REMOVE BELTS.
6. REPLACE GUIDE ROLLER AND FINGER TIGHTEN KNURLED RELEASE SCREW.
7. STORE DRIVE BELTS IN WELLS PROVIDED UNDER FRONT NAMEPLATE.
8. CONTINUE WITH STEP 4 IN REROLL LOADING INSTRUCTIONS.

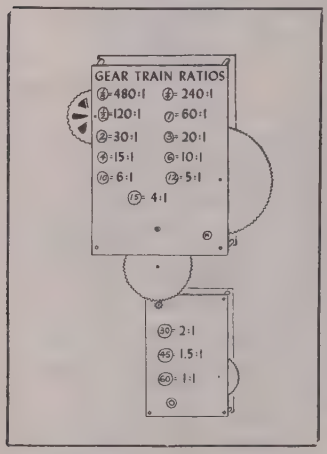
INSTRUCTIONS

FOR CHANGING GEAR TRAINS:

Loosen thumbscrew at upper left, open recorder. Remove gear train spring. Move gear train in direction of arrow on its case. Lift out from top. Don't force or lift from bottom.

Insert new gear train bottom in first. Slide into position, against arrow direction. Replace gear train spring.





FOR CHANGING SCALE and/or ACCESS WINDOW:

① Slide down top window. ② Snap out white front plastic bezel by pulling it towards you from top center. ③ Remove windows. ④ Replace scale in cutout provided in casting. ⑤ Install lower window. Two dimples at top of window must face out. Window drops in cutout provided. ⑥ Lay window in approximate position over lower window and replace plastic bezel, bottom in first, and snap sides into place by bowing out. ⑦ Check access window to be sure it slides freely.

FOR INSTALLING MODEL 2183 REFERENCE MARKER:

① Lower top access window. ② Remove front white plastic bezel by springing out from top center. ③ Replace existing access window with Reference Marker Assembly A-4641-G1. ④ Snap in white plastic bezel. Check reference marker window for proper seating. ⑤ To load chart, pull and rotate knob 90° to allow clearance. ⑥ Reference Marker Assembly still slides down (½" max.) to make notations on chart paper. ⑦ If reference marker is not needed, pull and rotate knob 90° to clear chart.

FOR CLEANING YOUR RECORDER: (Courtesy 3M Company)

Nextel BRAND **SUEDE COATING**

TOUGH, DURABLE, LUXURIOUS

This item is finished with "NEXTEL" Brand Suede Coating, a new and exciting finishing coat material from 3M Company. The unusual combinations of color making up this coating produce a visual sensation of depth and warmth comparable to fabrics and suede. This new finish imparts a unique visual quality and elegance to your item.

HOW TO CLEAN IT

Dust and light dirt marks can be easily removed with a damp sponge. Severe dirt marks — such as grease, oil, lipstick, crayon, etc. — can be removed with conventional cleaning techniques.

Suede Coating's toughness and resiliency combine to form a finish far superior to conventional gloss and textured finishes in abrasion and chip resistance. Try to scratch it! This impervious coating can be counted on for long lasting durability and service.

CALIBRATION

ALL RECORDERS ARE SUPPLIED FACTORY CALIBRATED. ADJUSTMENTS ARE CEMENTED AT THE FACTORY AFTER CALIBRATION AND SHOULD NOT BE READJUSTED UNLESS OPERATOR IS CERTAIN READINGS ARE IN ERROR

Mechanical Zero:
Each Rustrak recorder, with the exception of the Model 292 Event Recorder Series, has a galvanometer **Zero Adjustment** located under the front nameplate. (Dual channel recorders have two adjustments.) For access to the Zero Adjust screw, snap out the front nameplate using a fine blade screwdriver in the slot at the left of the plate.

Adjust galvanometer zero if recorder trace is above or below zero with galvanometer leads shorted and motor running. To reduce parallax errors, always zero the trace on the chart paper, not the stylus.

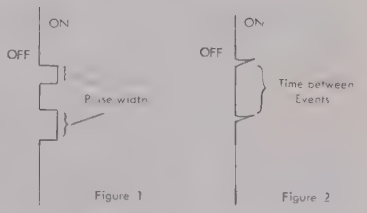
Model 2162 Pressure Recorder is zeroed similarly but with no connections to the fitting or with pressure generating equipment off.

DC Recorders: Except for the mechanical zero, no adjustments are provided for calibrating Models 288 and 291. All shunts and multipliers used in these recorders are fixed resistors permanently wired into the circuit.

If the recorder is consistently used over a narrow span of the calibrated scale and the zero reading is unimportant, the mechanical adjustment can be made at any point on the scale by calibrating against a standard meter connected across the galvanometer terminals and the source.

Model 2162 Pressure Recorder: We recommend that no calibration (except for zero adjustment) be attempted on this instrument. In case of trouble or erroneous readings, return the recorder to the factory for repair or calibration.

Event Recorders (Model 292 Series): No calibration is necessary, nor possible, on Rustrak event recorders. Stylus travel is fixed during manufacture for a pulse height of .040" to .060".



FIGURES 1 and 2: **Pulse width or Time between events determines chart speed. Minimum recommended time between events on "EE" chart paper is .025". *Table 1* shows motor and gear train combinations for minimum time of .050" and .025".**

The ability of an event recorder to register short duration events or rapidly reoccuring events is the only variable in this recorder. Both motor speed and gear train number affect this ability and their selection depends on either the **Minimum Event Time** or the **Minimum Time Between Events.**

Minimum Event Time, shown in *Figure 1*, is used when an event is more than transient in duration. The event appears as a rectangular pulse whose minimum width determines the choice of chart speed.

The other mode of operation, recording the number of successive events but not their duration, can also be used to determine chart speed. See *Figure 2*. Time between events is the important parameter in this mode. Either time is expressed in seconds.

The relationship between time in seconds and chart speed - - - based on a

.050" (1.27 mm.) minimum pulse width - - is:

$$\text{Chart speed (in./hr.)} = \frac{60}{(T/3)}$$

(T in seconds)

If 0.025" (.635 mm.) is acceptable as minimum pulse width or time between events, the formula becomes:

$$\text{Chart speed (in./hr.)} = \frac{60}{(T/1.5)}$$

(T in seconds)

Table 1.

MODEL 292 EVENT RECORDER CHART SPEED DATA

	Gear Train Assembly No.	#¼	#½	#1	#2	#3	#6	#10	#12	#15	#30	#60	
2 RPM Motor	Chart Speed (in./hr.)	¼	½	1	2	3	6	10	12	15	30	60	
	A or B (Sec.)	720	360	180	90	60	30	18	15	12	6	3	+
	A or B (Sec.)	360	180	90	60	30	18	15	12	6	3	1.5	±
8 RPM Motor	Chart Speed (in./hr.)	1	2	4	8	12	24	40	48	60	120	240	
	A or B (Sec.)	180	90	45	22.5	15	7.5	4.5	3.75	3	1.5	.75	+
	A or B (Sec.)	90	45	22 5	15	7.5	4 5	3.75	3	1.5	.75	.375	±
60 RPM Motor	Chart Speed (in./hr.)	7½	15	30	60	90	180	300	360	450	900	1800	
	A or B (Sec.)	24	12	6	3	2	1	.6	.5	.4	.2	.1	+
	A or B (Sec.)	12	6	3	2	1	.6	.5	.4	.2	.1	.05	±
100 RPM Motor	Chart Speed (in./hr.)	12½	25	50	100	150	300	500	600	750	1500	3000	
	A or B (Sec.)	14.4	7.2	3.6	1.8	1.2	6	.36	.3	.24	.12	.06	+
	A or B (Sec.)	7.2	3.6	1.8	1.2	.6	.36	.3	.24	.12	.06	.03	±

$$+ \quad .050" \text{ min} = \frac{60}{(T/3)} \qquad \pm \quad .025" \text{ min} = \frac{60}{(T/1.5)}$$

For example, a refrigerator manufacturer must know the number of times the refrigerator door is opened each day in a typical home and for how long it remains open each time. He determines that it takes three seconds to open the door then slam it shut. The analyst who will read the strip charts considers a minimum pulse width of.050" adequate for each event.

Minimum Event Time is 3 seconds; minimum pulse width is .050". Using the .050" formula, chart speed is 60/(3/3) or 60 inches per hour. (These figures are tabulated in *Table 1.*)

From *Table 1,* we find three possible combinations: a 2 rpm motor with a #60 gear train; an 8 rpm motor with a #15 gear train or a 60 rpm motor with a #2 gear train.

* * * * * *

A second example: A packing department ships in boxes of four different sizes, routing them over an endless belt to the trucking room. Four photocells at different heights count boxes and each photocell actuates a channel in a four-channel event recorder.

The first channel counts all boxes regardless of height, the second all boxes above six inches, the third all boxes above a foot and the last channel only sees boxes taller than two feet.

On a busy day, boxes pass by every six seconds but in mixed heights. The operator feels he can read events easily with only .025" spacing between each on the chart paper.

The first channel, the busiest, determines chart speed. Minimum time between events is 6 seconds. Using the .025" formula (or *Table 1*), chart speed is 60/(6/1.5) or 15 inches per hour.

From *Table 1,* we find the following possible combinations: a 2 rpm motor with #15 gear train or a 60 rpm motor with a #½ gear train.

* * * * * *

In the first example, three combinations are possible; in the second, two are available. Which do we choose? * * * * * *

Returning to the first example: Suppose the analyst finds the .050" = 3 second minimum pulse width too narrow for accuracy. He now wants a minimum of

.100" = 3 seconds or twice the original figure. Since the time element is the same but the desired minimum pulse width is twice the original, chart speed must be doubled.

If he selected the 2 rpm motor, his event recorder will need a new motor and gear train to record these conditions. But, if he bought the 8 rpm motor, he merely changes the gear train to a #30 to record at twice the original speed.

Choice of motor and gear train is a trade-off between economy and versatility. The 2 rpm motor/#1 gear train combination is standard if speed isn't specified when ordering. However, there's no adder if a gear train is specified ... meaning that a 2 rpm motor can be used for speeds up to 60 inches per hour if your purchase order specifies the higher gear train number.

Eight rpm, 60 rpm and 100 rpm motors are furnished at added cost. You can choose from a complete selection of gear trains to vary speeds from ¼ inch per hour to 3000 inches per hour.

AC RECORDERS: Calibration Notes:

Rustrak AC recorders use a permanent magnet, moving coil type galvanometer commonly known as a d'Arsonval movement, and a copper-oxide bridge rectifier.

The current-voltage characteristics of the metallic rectifier are such that the rectifier resistance varies with current flow, increasing nonlinearly as current decreases. As a result, rectifier-type instruments often have scales with markings crowded at the low end.

To reduce this crowding and render scales more linear, many Rustrak recorders come wired with a short across one leg of the bridge rectifier. This short is **not** an error and will affect calibration and scale markings if removed.

Scales in Rustrak AC recorders are calibrated in **rms** readings. Since the output of the metallic rectifier is proportional to the average AC value, appreciable error may be introduced if these recorders are used to read other than true sinusoidal waveforms. The error depends on amplitude and phase of harmonics present.

Calibration should always be done at 25°C. While it's possible to calibrate most recorders within tolerance without regard to ambient temperature, it's also equally probable that you'll want the best accuracy from your recorder. The major source of temperature error in AC recorders is the temperature coefficient of the rectifier and meter.

The TC of the forward resistance in a metallic rectifier is about 1%/°C. (varies with manufacturers) in a negative direction, that is, meter readings decrease with a rise in temperature. Copper wire meter coils have a TC of +0.39%/°C. or meter increase in resistance with a rise in temperature.

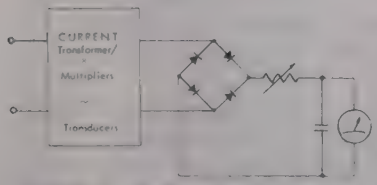


FIGURE 3. Basic wiring to Rustrak AC recorders. Note rheostat in series with galvanometer. Since rheostat adjustment is cemented after calibration by the factory, no calibration should be needed unless components are changed.

AC recorders should be calibrated at the frequency of use, whether 50, 60 or 400 Hz. A short explanation follows the specific instructions on AC recorders.

All Rustrak AC recorders have calibration adjustments to compensate for the variations in rectifiers, multipliers or transducers and for aging in the components. Models 288R, 2118 and 2107 use a rheostat in series with the galvanometer as shown in *Figure 3.*

Model 288R: This recorder, whether one or more ranges, is calibrated using a variable AC source and an accurate standard meter for reading rms values. Wire test circuit as in *Figure 4* and calibrate as follows:

1. With no voltage applied, adjust meter zero as shown in opening paragraph of this section. Apply motor power.
2. Select a range whose full scale value is compatible with the standard meter and the variable AC source.
3. Adjust rheostat until recorder reads the same as the standard meter. Record a trace. Don't rely on visual indications for this adjustment.
4. Galvanometer should be in tolerance on other ranges.

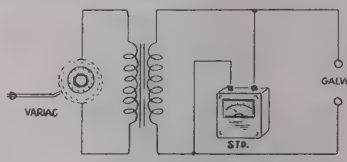


FIGURE 4. Test circuit for calibrating AC voltage recorders. Adjust Variac for full scale galvo reading then adjust internal rheostat until trace is same as standard reading.

Model 2118: This recorder model should not be calibrated in the field unless an instrument transformer or other alternating current read-out equipment is available.

To calibrate, connect the common and the 5 ampere terminals in line with the instrument transformer connected to its indicating instrument. Apply motor power. Open front panel of recorder by loosening thumbscrew and lay instrument on its side. Be sure meter is mechanically zeroed first.

Rheostat is housed in the transducer case mounted on the rear case panel and may be adjusted using a long, insulated screwdriver. Use safety precautions as potentially lethal currents are exposed.

Do not calibrate unless adequate calibrating equipment is available.

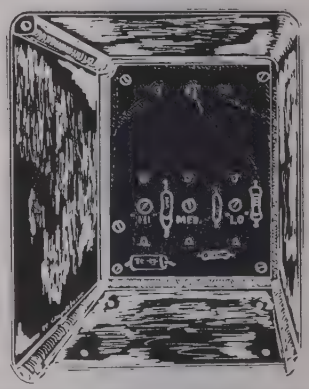


FIGURE 5. Range adjustments for Rustrak Model 293 series. Low range is always on the right. Pots are located behind circuit board in the positions shown.

Model 2107: Since this recorder uses a clamp-on one turn instrument transformer (commonly called transducer) to measure alternating currents in excess of most lab capabilities, it's suggested that the internal rheostats not be adjusted. Return this recorder to the factory for trouble-shooting or calibration.

Model(s) 293: Either of these recorder models may be calibrated using the test wiring shown in *Figure 4*. However, each range has an individual adjustment. See *Figure 5* for range identification. Be sure to zero the meter before calibrating at full scale.

Model 2120: Since this instrument combines a current channel with a voltage channel, most foregoing instructions apply to this recorder.

1. Zero both galvanometers by adjusting screws under the front nameplate. Apply motor power.
2. Calibrate the current channel using directions given for the Model 2118.
3. The voltage channel is not usually adjustable. In case you ordered a special recorder with tailored ranges, refer to *Figure 5* for the location

of calibrating pots and follow the directions given for Model 293 to calibrate.

Model 2113: Field calibration of the current channel on this recorder is not recommended. Adjustments labeled "Amps" in the rear of the instrument should not be touched unless accurate equipment to calibrate clamp-on transducers is available. To calibrate voltage channel:

1. Set selector switch to Voltage.
2. Set front panel range selector to 150V. range.
3. Mechanically zero the galvanometer.
4. Clip voltage leads into a circuit arrangement shown in *Figure 4*.
5. Set Variac to read exactly 150 VAC on the standard meter.
6. Adjust pot labeled "150V" on rear case of recorder until trace prints steadily at 150V.
7. Other ranges are automatically calibrated.

Model 2164: This series of recorders can be calibrated by comparing readings against lab type dynamometer standards. These standards are available at 0.1% accuracy and in single or double elements, in the 2½ element configuration or in crossed-coils. To calibrate:

1. Adjust mechanical zero under front nameplate. Apply motor power.
2. Wire watt recorder across line(s) following installation instructions. Use caution. Currents are potentially lethal.
3. Wire dynamometer standard to the same source and using same load. Use caution. Currents are potentially lethal.
4. Adjust rheostat located in the lower half of the rear case panel, accesible by opening recorder and dropping front panel assembly. Calibrate on high end of scale since dynamometer has compressed scale at low end.

Burden: The amount of power drawn by the instrument from the circuit under test must be taken into consideration when calibrating the watt recorders against a dynamometer. Dynamometer coils require between 0.5 and 1 watt power to develop torque and often more on multi-range instruments. Check your standard dynamometer to compute burden accurately. Current burden of the transducer used in the Model 2164 recorder series is 2.5 VA. Remember that burden, by affecting the load either instrument sees, may cause an appreciable error during calibration.

FIGURE 6: Location of range adjustments for Model 2186 AC recorder. Panel is located inside instrument at rear of case.

Model 2186: This model requires a meter standard with an accuracy of 0.1% or better. Calibrate as follows:

1. Mechanically zero galvanometer by adjusting screw under front nameplate. Apply motor power.
2. Hook up test circuit as in *Figure 4*. Be sure Variac and transformer can furnish voltages of 106, 124, 212, 230, 248, 420, 460 and 500 VAC.
3. Open recorder by loosening knurled thumbscrew and lay on its side.
4. Feed in 106 VAC to the bottom input terminals, monitoring this voltage on the meter standard.
5. Refer to *Figure 6* for location of ad-

justments. These adjustments are **not** labeled in the recorder. Adjust the uppermost pot (marked "A" in *Figure 6*) until trace prints at **½ division below 106 V.**

6. Vary input voltage to 124 VAC and adjust second pot (labeled "B" in *Figure 6*) for a trace **½ division above 124 V.**
7. To the next input terminals, apply 230 VAC. Adjust pot "C" for center scale on chart paper. Be sure to print out readings on the chart.
8. Vary voltage to 212 VAC. Trace should be within ½ division.
9. Vary input to 248 VAC. Trace should be within ½ division.
10. If trace is not within ½ division on steps 8 & 9, readjust for center scale as in step 7.
11. Apply 460 VAC to the highest range terminals. Adjust pot "D" for center scale trace.
12. Vary input to 420 VAC. Trace should be within ½ division.
13. Change input to 500 VAC. Again trace should be within ½ division.
14. Return to step 11 if trace is not within tolerance.

Frequency considerations: Rustrak recorders are warranted in accuracy only at the frequency of calibration. This is not to imply that some AC recorders can't be used at other frequencies. The reverse may be true. But since Rustrak has no control over waveforms applied to its recorders, it cannot guarantee accuracy beyond certain stated limits.

All current reading recorders should never be used at frequencies other than the calibration frequency which is also the design frequency. This limitation also applies to recorders using clamp-on transducers. Transformers and transducers designed for one frequency may be damaged when used at other frequencies because of a change in impedance.

AC voltage recorders however, with the possible exception of the Model 2186, can often be used at frequencies up to 400 Hz without recalibration. This use - within tolerance limits - is not guaranteed by Rustrak but merely stated. Every effort is made to use non-reactive components but the factory exercises no control over the reactance of components manufactured for us when reactance is not a prime specification.

Galvanometers in AC recorders are calibrated to read the **rms** value of a sinusoidal input. The output of the rectifier is average current and the ratio between **rms** to average is 1.11. If the input waveform is not sinusoidal, errors in the **rms** reading may occur. With a full-wave rectifier, a 50% second harmonic may introduce an error of up to 10% on the plus side while a 50% third harmonic can produce an error of -10% to +16% depending on phase relationships.

Frequency errors in meter rectifiers are considered negligible since the internal shunt capacitance becomes evident only at 1Khz and above where it may cause an error of up to 0.5%.

NON-SYMMETRICAL WAVEFORMS

To be on the safe side, check calibration before using. And ... if in doubt, stick to the frequency specified at the time of purchase.

TEMPERATURE RECORDERS:

Model 2122: This pyrometer reads the output of Type J (I/C) or type K (C/A) thermocouples in the resistance range of 0 to 23 ohms. Both I/C and C/A thermocouples are furnished with the instrument, and the recorder is factory calibrated for the I/C thermocouple.

The Model 2122 consists of three basic elements: a thermocouple which generates an EMF proportional to the difference in temperature between its sensing and non-sensing ends; a cold-junction compensating network, and a galvanometer to measure the thermocouple output EMF.

Millivolt pyrometers are resistance sensitive and must be recalibrated when changing from I/C to C/A thermocouples (or vice-versa), when changing thermocouple lead lengths or wire size. The resistance loop in the Rustrak Model 2122 is 210 ohms making it less sensitive to misadjustment. A "CAL" adjustment is provided on the rear case for matching the recorder to thermocouples in the 0 to 23 ohm range.

°C. Calibration:

1. With thermocouple leads disconnected and "A" style paper installed, zero the galvanometer with the Zero Adjustment under the front nameplate.
2. Connect the negative terminal of the thermocouple to be used (be sure type is same as indicated on range switch markings) to the yellow binding post on the rear case and the positive terminal to the white binding post.
3. Set selector switch on rear case to "CAL".
4. With the sensing end of the thermocouple at 25°C., press "CAL" button, adjust the white nylon "CAL" adjustment until recorder prints on the 45th paper division. This adjustment should be made against an accurate lab thermometer, and corresponds to the "CAL" marking on the chart scale. If temperature is not 25°C., set trace accordingly: As each division on the chart paper equals 5°C., add or subtract difference above or below 25°C. For instance, 20°C. should print on the 44th division, 30°C. on the 46th. Allow several minutes for trace to stabilize. Keep access window closed during calibration to prevent change due to air currents.
5. Switch to desired range. Pyrometer is ready to use.

INPUT EMF FOR THE FOUR RANGES OF A °C. READING MODEL 2122 IS:		
-20 to +230 (I/C)	0.0 mv. = 9 division	11.06 mv. = 50 division
-20 to +730 (I/C)	0.0 mv. = 3 division	39.47 mv. = 50 division
-20 to +480 (C/A)	0.0 mv. = 4.5 division	18.73 mv. = 50 division
-20 to +1480 (C/A)	0.0 mv. = 1.5 division	53.68 mv. = 46 division

To check calibration on any of the four ranges, use a stable MV supply with a source resistance less than one ohm. Connect supply to recorder using I/C or C/A type material as shown on range switch markings.

The cold junction compensating network is not adjustable. Maximum error due to cold junction variation from 15 to 46°C. is ±3.3°C.

°F. Calibration:

1. With thermocouple leads disconnected and "H" style paper installed, zero the galvanometer.

2. Connect the negative terminal of the thermocouple to be used (be sure type is the same as indicated on range switch markings) to the yellow binding post on the rear case and the positive terminal to the white binding post.
3. Set selector switch on rear case to "CAL".
4. With the sensing end of the thermocouple at 77°F., press the "CAL" button and adjust the white nylon "CAL" adjustment until recorder prints on the 35th paper division. This adjustment should be made against an accurate lab thermometer, and corresponds to the "CAL" marking on the chart scale. If temperature is not 77°F., set trace accordingly: As each division on the chart paper equals 10°F., add or subtract difference above or below 77°F. For instance, 67°F. should print on the 34th division, 87°F. on the 36th. Allow several minutes for trace to stabilize. Keep access window closed during calibration to prevent change due to air currents.
5. Switch to desired range. Pyrometer is ready to use.

INPUT EMF FOR THE FOUR RANGES OF A °F READING MODEL 2122 IS:

0 to 400 (I/C)	-1.83 mv. = 1 div.	+9.33 mv. = 39 div.
0 to 1200 (I/C)	-1.29 mv. = 1 div.	+33.54 mv. = 39 div.
0 to 800 (C/A)	-1.21 mv. = 1 div.	+16.00 mv. = 39 div.
0 to 2400 (C/A)	-0.37 mv. =1 div.	+50.95 mv. = 39 div.

To check calibration on any of four ranges, use a stable MV supply with a source resistance of less than one ohm. Connect supply to recorder using I/C or C/A type material as shown on range switch markings.

Model 2133: This temperature recorder series uses thermistor probes for temperature sensing. Because spans and ranges vary so widely in the Model 2133, it is not recommended that calibration be attempted in the field. The resistance values of the bridge circuit and the many ranges and spans built by Rustrak on customer order would require many booklets this size to be complete.

Meter zero: Most 2133 recorders have a center zero galvanometer though a zero-left galvanometer is sometimes used for special ranges. Check your pointer position with the power off and clamper bar raised to allow free stylus swing. Adjust zero by varying Zero Adjust screw under front nameplate.

TEMPERATURE Conversion Table

°C		°F
149	**300**	*572*
121	**250**	*482*
93	**200**	*392*
66	**150**	*302*
60	**140**	*284*
54	**130**	*266*
49	**120**	*248*
43	**110**	*230*
37.8	**100**	*212*
36.7	**98**	*208.4*
35.0	**95**	*203*
32.2	**90**	*194*
29.4	**85**	*185*
26.7	**80**	*176*
23.9	**75**	*167*
21.1	**70**	*158*
15.6	**60**	*140*
10.0	**50**	*122*
4.44	**40**	*104*
-1.11	**30**	*86*
-6.67	**20**	*68*
-12.2	**10**	*50*
-17.8	**0**	*32*
-23.3	**-10**	*14*
-28.9	**-20**	*-4*
-34.4	**-30**	*-22*
-40.0	**-40**	*-40*
-45.6	**-50**	*-58*
-73.3	**-100**	*-148*
-101	**-150**	*-238*
-129	**-200**	*-328*
-157	**-250**	*-418*
-169	**-273**	*-459.4*
-184	**-300**	.....
-273.2	**-459.7**	.....

Numbers in BOLD face, center, refer to temperature either in degrees C or F to be converted. If converting from °F to °C, the equivalent is found in column on left. If converting from °C to °F, the answer is found in column on right

Temperatures not shown: Convert °F to °C by subtracting 32 degrees, multiplying by 5, dividing by 9. Convert °C to °F by multiplying by 9, dividing by 5, adding 32 degrees.

Calibration check: With instrument wired and slide switch on rear case at "ON", unplug the thermistor probe jack. A trace between full scale and -2% of span indicates correct calibration.

Probes sold for use with the Model 2133 are interchangeable. Their resistance vs. temperature is:

20°C	2806 Ohms	±1%
21°C	2686 "	±1%
22°C	2570 "	±1%
23°C	2458 "	±1%
24°C	2352 "	±1%
25°C	2253 "	±1%
0°C	7396 "	±1%

When measuring, be sure the instrument used applies less than 0.5 volt across the probe. Otherwise, self-heating will introduce considerable error.

SEE BACK COVER FOR CALIBRATE INFORMATION

Model 2144: This temperature recorder series uses nickel wire probes for temperature sensing. Since spans and ranges are largely custom designed and each require a new set of bridge ratio arm values, it is not recommended that calibration be attempted in the field.

Meter zero: Most 2144 recorders have a center zero galvanometer though a zero-left galvanometer is sometimes used for special ranges. Check your pointer position with power off and clamper bar raised to allow free stylus swing. Adjust zero by varying Zero Adjust screw under the front nameplate.

Calibration check: With instrument connected to its normal supply and slide switch on rear case at "ON", unplug the nickel wire probe jack. A trace between full scale and -2% of span indicates correct calibration.

Model 1441 and 1442 probes are normally interchangeable. Power to the Model 2144 recorder should be removed when changing probes. Their resistance vs. temperature is:

70°F	200 Ohms	±1%
75°F	203.2 "	±1%
80°F	206.2 "	±1%
32°F	177.76 "	±1%

When measuring, be sure instrument used applies less than 2 ma. through the probe. Otherwise, self-heating will produce appreciable error.

SEE BACK COVER FOR CALIBRATE INFORMATION.

Model 2144A: A differential temperature recorder records the difference in temperature between a reference probe and a test probe. The scale shows the difference between the two.

Scales are calibrated in one of three ways:

1. Zero center with unknown temperature excursions above or below the reference (-X, Ref, +X)
2. Zero left with temperature scale above reference. (Ref, +X)
3. Zero left with temperature scale below reference. (Ref, -X)

Calibration Adjustments: Adjust mechanical galvanometer zero adjust-

ment located under front nameplate. Instruments are either zero center or zero left. Always zero with power off and with clamper raised to allow free stylus movement.

The instrument itself may be self-checked for internal calibration accuracy. Plug in the instrument, flip side switch to "Record" position and disconnect both probes. A trace equal to full scale (+0-2%) indicates correct calibration.

To balance probes, plug in both probes, place them near each other and allow ten minutes to stabilize temperatures. Equipment should be on at this time. Adjust the balance control on the back panel for a scale reading of 0°. Rebalancing is not necessary until probes are interchanged.

Jack number 2 (see back panel) connects to the reference probe. Be sure probe #2 is used in this way.

The actual operating temperature of both probes must be within the span designated on the scale. Though the range of the Model 2144A temperature recorders can be between -100°F. to +600°F., the span within this range and scale calibration determines the actual operating temperature of the probes. For instance, a differential recorder with a scale differential of +50°F. must be used to monitor temperature within the limits of the 100° span marked on the scale. Outside these limits, the accuracy specifications are not necessarily valid.

Resistance versus temperature of the probe is:

32°F.	177.8 Ohms	±1%
70°F.	200.0 "	±1%
75°F.	203.2 "	±1%
80°F.	206.2 "	±1%

Equipment used should limit current to 1 ma. or less through the sensor. Self-heating will introduce an error.

Model 2155: This thermocouple temperature recorder is calibrated specifically for use with the I/C or C/A thermocouple supplied. Errors will result if used with thermocouples having lead resistance other than 2.1 ohms for I/C or 3.5 ohms for C/A. Recorders calibrated for I/C have red and white binding posts. Recorders calibrated for C/A have red and yellow binding posts. The colors correspond to the thermocouple lead wire colors. In both cases, red is the minus terminal. The thermocouple material that the instrument is calibrated for is printed on the scale.

Compensation for ambient variation: If the instrument is used in ambients considerably different from 25°C (77°F), it may be necessary to change the galvanometer adjustment. If it is possible to compare the probe temperature to an accurate thermometer, simply make the adjustment necessary to obtain agreement between the recorder and thermometer - i.e. - if the thermometer reads 90°F. make the recorder read 90°F. The galvanometer adjustment is located under the front nameplate.

Model 2166: Refer to Model 2144 for calibration instructions for this series of temperature recorders.

SEE BACK COVER FOR CALIBRATE INFORMATION

Model 2194: This 10 millivolt DC recorder contains a medium gain amplifier which drives a one ma. full scale galvanometer. The input resistance is 10,000 ohms. A 10 millivolt change will cause full scale deflection.

This model is intended primarily for use with low resistance sources such as thermocouples, strain gages, and low resistance bridges. The error due to amplifier loading with a 100-ohm source is 1%.

Temperature drift is comparatively high with high source resistance (above 1000 ohms).

To record from high impedance sources:

1. Remove power and adjust galvanometer zero.
2. Apply power, and allow one-half hour warm-up with motor RECORD switch on.
3. Short input terminals and adjust ZERO adjustment on rear panel for reading of zero.
4. Remove short and adjust BALANCE for a reading of zero. Zero should not shift with the terminals shorted or unshorted.
5. Gain adjustment is not normally necessary. But if calibration is made, use an accurate 0 to 10 mv generator whose output resistance is under 100 ohms to eliminate error due to amplifier loading

NOTE: DO NOT APPLY VOLTAGES IN EXCESS OF ±1 VDC. PERMANENT DAMAGE TO THE AMPLIFIER MAY RESULT.

In many applications it may be necessary to reduce the sensitivity of the amplifier. To reduce the current sensitivity, shunt the input terminals as with any galvanometer.

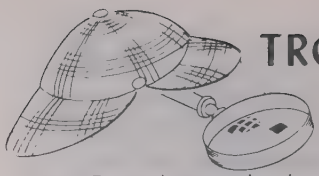
CURRENT SENSITIVITY	*APPROX. SHUNT VALUE*
1 Microamp	none
10 Microamp	1000 Ohms
100 Microamp	100 Ohms
1 Milliamp	10 Ohms
1 Ampere	0.01 Ohm

To decrease the voltage sensitivity, the input should be shunted with a 1000 ohm resistor to improve stability. Voltage sensitivity then becomes 100 K/volt. A multiplier resistor is series wired as shown below.

VOLTAGE SENSITIVITY	*APPROX. SERIES RESISTANCE*
10 MV.	none
20 MV.	1000 Ohms
100 MV.	9000 Ohms
1 Volt	99,000 Ohms
10 Volts	1 Megohm

Model F204: No calibration is required on the F204 Controller feature. However, the following test procedure can be used for preventative maintenance or regular instrument testing schedules.

1. Calibrate recorder used with controller feature.
2. Feed signal to recorder until galvo reads exactly center scale.
3. Adjust controller setpoint knob until relay actuates or deactuates. Swing knob back and forth to make sure that very narrow bandwidth is available. There should be practically no movement of the pointer on the knob between on and off.
4. With setpoint knob set at Control point, check if knob pointer is at center mark on dial. If not, loosen set screw and move pointer to center mark. Retighten set screw.
5. Check correlation of pointer position at 0, 20, 40, 60 and 100% points on scale. A deviation of one division at any point is acceptable.



TROUBLESHOOTING AND REPAIR

Your Rustrak recorder is engineered to withstand shock and abuse. It requires no special maintenance schedule or lubrication.

But, as a precision instrument, your recorder should receive the best of care. Most problems during use can be traced to improper chart paper loading, incorrect wiring or mishandling of your recorder.

The following chart will help diagnose and cure many problems in the field.

SYMPTOM	*POSSIBLE CAUSE*	*SERVICE HINT*
Meter records above or below zero with no signal applied.	Meter zero out of adjustment	Remove front nameplate. Adjust mechanical zero.
Meter can't be zeroed.	Stylus bent; cross arm bent.	Return instrument to factory.
Meter reads zero with signal applied.	Meter open. Connections to meter open; multiplier resistor open.	Check meter (Do not use VOM) Check wiring to galvo. Check plug and terminal wiring Read out multiplier resistor with VOM.
Meter hangs above zero.	Dust in meter pivots	Return recorder to factory.
Offset stylus visibly bent.	Meter has been overloaded.	Return recorder to factory.
Recorder has continuous trace.	Stylus bent; rubs on chart paper.	Return to factory.
Meter reads consistently below zero.	Polarity to meter reversed.	Check wiring to mating socket. Check polarity of signal being recorded.
Reroll mode: Paper crinkles at view window.	Take-up spool not seated to engage drive gear.	Unlatch retaining clip; reseat take-up spool in further notch.
Reroll: Paper doesn't drive through recorder.	Perforations not engaged in drive drum. Gear train doesn't engage drive drum.	Reload following loading instructions. Bend tabs on gear train slightly for end play; Bend gear train spring for more tension.
Tear-off: Paper doesn't drive through tear-off slot.	Drive belts not seated on take-up roller. Also riding in large center groove of drive belt roller.	Seat drive belts as shown in loading instructions.
Paper tears on drive drum.	Roll of chart paper is spiraled.	Reload taking care chart paper is perfectly aligned.
Chart advance thumbwheel is locked.	Tab that disengages gear train is bent.	Remove gear train and straighten tab.

An exploded view of your recorder is shown in the centerfold.

Rustrak stocks all major parts and subassemblies at the factory.

Other than service hints outlined in this manual, we recommend our factory service by technicians trained and equipped to trouble-shoot and repair your instrument.

Should you wish factory assistance to repair or modify your instrument, pack your recorder in a carton equal to the original packaging. Insure to full value and ship prepaid.

With your packing slip, please include a letter giving full details of the problem encountered or modification requested.

Send to:

Customer Service Department
Rustrak Instrument Division
Gulton Industries Inc.
Municipal Airport
Manchester, N. H. 03103

ADDITIONAL RECORDER INFORMATION

OPERATING SPEEDS

CHECK TAG INSIDE YOUR RECORDER FOR SPEEDS

WRITING SPEED

The Writing Speed or the number of stylus strikes per second depends on the motor speed selected.

$$\frac{\text{motor speed (rpm)}}{4}$$

For example, a recorder supplied with the standard 2 rpm motor prints once every two seconds. Other motors from ½ rpm (one strike each 8 seconds) to 16 rpm (four strikes per second) are available. Check your recorder for motor speed.

CHART SPEED

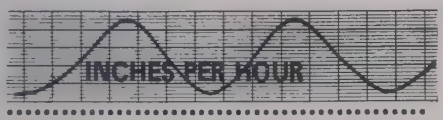
The Chart Speed in inches per hour depends on both motor speed and the selection of a gear train.

$$\frac{\text{motor speed (rpm) x gear train number}}{2}$$

A 2 rpm motor, for example, coupled with a Number 1 gear train results in a chart speed of one inch per hour. By choice of motors and gear trains, the range options lie between the limits of 1/32" per hour to 480 inches per hour.

A higher number gear train increases chart speed. Replacing with a smaller number, conversely, reduces chart speed.

Drive Motor (rpm)



1/2	1/32	1/16	1/8	1/4	1/2	3/4	1	1½	2½	3	3¾	7½	11¼	15
1	1/16	1/8	1/4	1/2	1	1½	2	3	5	6	7½	15	22½	30
2	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30	45	60
4	1/4	1/2	1	2	4	6	8	12	20	24	30	60	90	120
6	3/8	3/4	1½	3	6	9	12	18	30	36	45	90	135	180
8	1/2	1	2	4	8	12	16	24	40	48	60	120	180	240
10	5/8	1¼	2½	5	10	15	20	30	50	60	75	150	225	300
12	3/4	1½	3	6	12	18	24	36	60	72	90	180	270	360
16	1	2	4	8	16	24	32	48	80	96	120	240	360	480
	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30*	45*	60*

* separated dots

Gear Train Assembly No.

TRACE DENSITY

The Trace Density or number of strikes per inch of chart travel is determined by the gear train.

$$\frac{1800}{\text{gear train number}}$$

As an example, our Number 1 gear train produces 1800 strikes per inch of chart travel. Resultingly, the trace appears as a continuous, unbroken line.

Factory available gear trains allow selections in the range of 14,400 to 30 strikes per inch travel.

However, gear trains #30, 45 and 60 produce a lightly recorded trace since chart speeds are proportionately increased with these gear train assemblies.

Generally, darker traces (more strikes per inch of chart travel) are obtained by combining a *faster* drive motor with a *slower* gear train. This combination can produce the same chart speed. For instance, the mating of a 2 rpm motor and a #1 gear train or that of a 4 rpm motor and a #½ gear train both cause the chart to travel at the rate of one inch per hour. But the first combination (#1 gear train) results in 1800 strikes per inch while the second (#½ gear train) produces a trace having 3600 strikes in the same inch of chart travel.

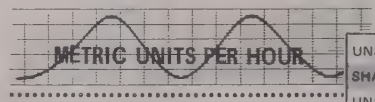
The gear train option is changeable in the field. Motors, on the other hand, are not usually changed in the field, though they may be.

CONVERSION CHART

INCHES FRACTIONAL	INCHES DECIMAL	MILLIMETERS
1/64	.0156	.39624
1/32	.0312	.79248
3/64	.0469	1.1912
1/16	.0625	1.5875
3/32	.0938	2.3825
1/8	.1250	3.1750
3/16	.1875	4.7625
1/4	.2500	6.3500
3/8	.3750	9.5250
7/16	.4375	11.1125
1/2	.5000	12.7000
9/16	.5625	14.2875
5/8	.6250	15.8750
11/16	.6875	17.4625
3/4	.7500	19.0500
7/8	.8750	22.2250
1	1.000	25.4000
2	2.000	50.8000

To convert to millimeters, use chart above. Chart Speed in metric units is charted below.

Drive Motor (rpm)



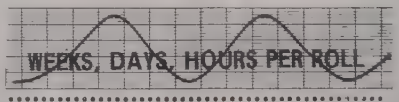
UNSHADED (LEFT): MILLIMETERS
SHADED (CENTER): CENTIMETERS
UNSHADED (RIGHT): METERS

1/2	.792	1.59	3.18	6.35	12.7	19.1	25.4	38.1	63.5	76.2	95.3	19.1	29.8	38.1
1	1.59	3.18	6.35	12.7	25.4	38.1	50.8	76.2	12.7	15.2	19.1	38.1	57.2	76.2
2	3.18	6.35	12.7	25.4	50.8	76.2	10.2	15.2	25.4	30.5	38.1	76.2	1.14	1.52
4	6.35	12.7	25.4	50.8	10.2	15.2	20.3	30.5	50.8	61.0	76.2	1.52	2.29	3.05
6	9.53	19.1	38.1	76.2	15.2	22.9	30.5	45.7	76.2	91.4	1.14	2.29	3.43	4.57
8	12.7	25.4	50.8	10.2	20.3	30.5	40.6	61.0	1.02	1.22	1.52	3.05	4.57	6.10
10	15.9	31.8	63.5	12.7	25.4	38.1	50.8	76.2	12.7	1.52	1.91	3.81	5.72	7.62
12	19.1	38.1	76.2	15.2	30.5	45.7	61.0	91.4	1.52	1.63	2.29	4.57	6.86	9.14
16	25.4	50.8	10.2	20.3	40.6	61.0	81.3	1.22	2.03	2.44	3.05	6.10	9.14	12.2
	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30*	45*	60*

Gear Train Assembly No.

* separated dots

Drive Motor (rpm)



Duration of operation with one 63 ft. long spool of chart paper.

1/2	144 WKS	72 WKS	36 WKS	18 WKS	9 WKS	6 WKS	756 HRS	21 DYS	302.4 HRS	252 HRS	201.6 HRS	100.8 HRS	67.2 HRS	50.4 HRS
1	72 WKS	36 WKS	18 WKS	9 WKS	756 HRS	21 DYS	378 HRS	252 HRS	151.2 HRS	126 HRS	100.8 HRS	50.4 HRS	33.6 HRS	25.2 HRS
2	36 WKS	18 WKS	9 WKS	756 HRS	378 HRS	252 HRS	189 HRS	126 HRS	75.6 HRS	63 HRS	50.4 HRS	25.2 HRS	16.8 HRS	12.6 HRS
4	18 WKS	9 WKS	756 HRS	378 HRS	189 HRS	126 HRS	94.5 HRS	63 HRS	37.8 HRS	31.5 HRS	25.2 HRS	12.6 HRS	8.4 HRS	6.3 HRS
6	12 WKS	6 WKS	21 DYS	252 HRS	126 HRS	84 HRS	63 HRS	42 HRS	25.2 HRS	21 HRS	16.8 HRS	8.4 HRS	5.6 HRS	4.2 HRS
8	9 WKS	756 HRS	378 HRS	189 HRS	94.5 HRS	63 HRS	47.25 HRS	31.5 HRS	18.9 HRS	15.75 HRS	12.6 HRS	6.3 HRS	4.2 HRS	3.15 HRS
10	50.4 DYS	604.8 HRS	302.4 HRS	151.2 HRS	75.6 HRS	50.4 HRS	37.8 HRS	25.2 HRS	15.12 HRS	12.6 HRS	10.08 HRS	5.04 HRS	3.36 HRS	2.52 HRS
12	6 WKS	21 DYS	252 HRS	126 HRS	63 HRS	42 HRS	31.5 HRS	21 HRS	12.6 HRS	11.5 HRS	8.4 HRS	4.2 HRS	2.8 HRS	2.1 HRS
16	756 HRS	378 HRS	189 HRS	94.5 HRS	47.25 HRS	31.5 HRS	23.675 HRS	15.75 HRS	9.45 HRS	7.875 HRS	6.3 HRS	3.15 HRS	2.1 HRS	1.575 HRS
	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30*	45*	60*

Gear Train Assembly No.

* separated dots

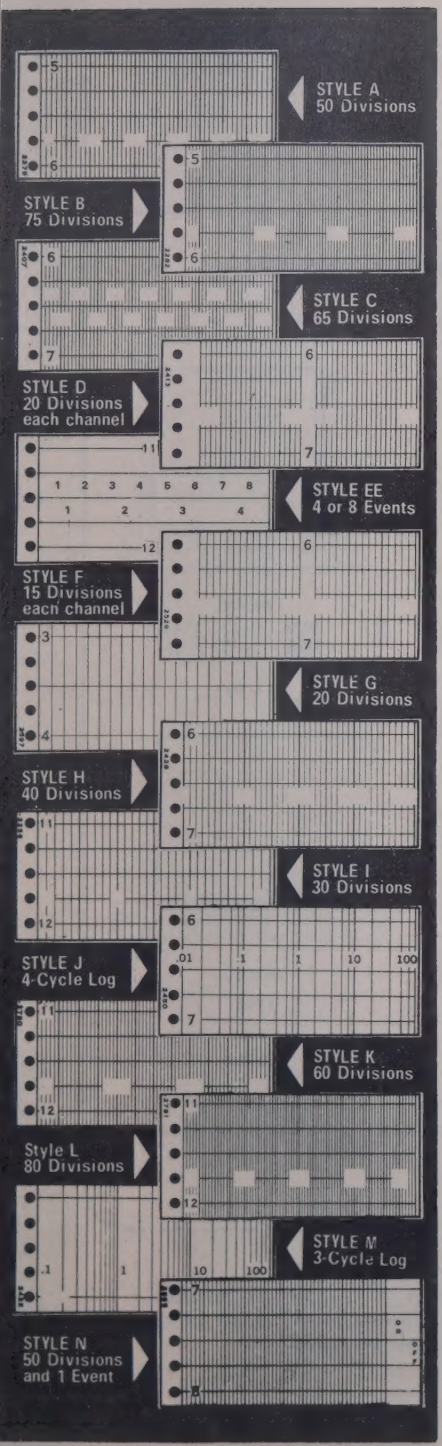


CHART PAPER

SPECIFICATIONS

The use of pressure-sensitive, inkless writing chart paper results in permanent, smudge-proof recording. A standard spool of chart paper is 63 feet long, allowing continuous recording for a month at a chart speed of 1 inch per hour.

This rectilinear graph paper is 2-9/16 inches wide with a useable scale width of 2-5/16 inches for single channel recorders. Dual channel recorders use one inch width per channel.

Chart paper spools are individually boxed with six boxes to the carton.

TIME IMPRINT AND WARNING

Each foot of graph paper is numbered 1 to 12 for time setting. In turn, each inch is divided into equal segments. A printed warning to "Renew Chart" begins six feet from the end of the roll and is repeated every foot until the end of the spool.

DURATION OF SPOOL

A spool lasts:

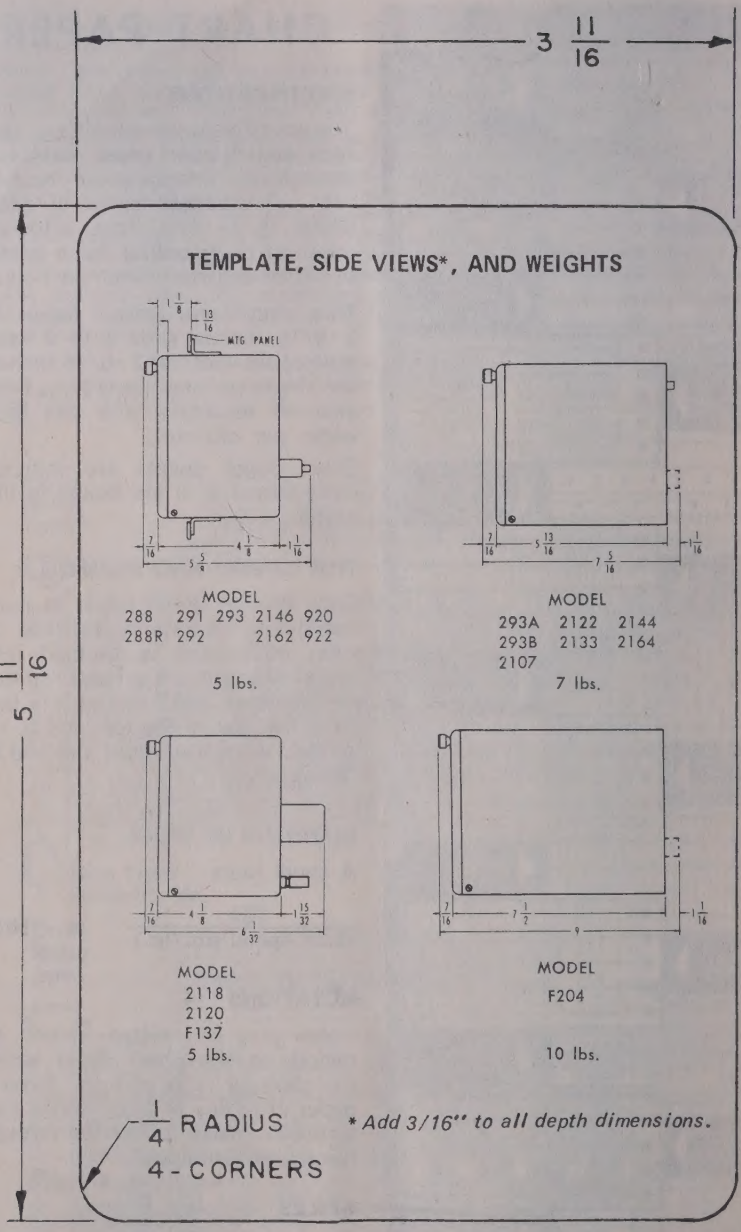
$$\frac{756}{\text{chart speed (in./hr.)}} = \text{Hrs.}$$

NOTATIONS

Notes may be written in pen or pencil on the chart paper while the recorder is operating. Even a paper clip, key or blunt stylus can be used to make a notation through the access window.

STYLES

The availability of many chart paper styles enhances the versatility of your recorder. Overlay, legend printing and other styles are available from the factory.



1. Refer to Page 13 for outline of mounting brackets.
2. If cutout is made to size shown, Model 2196 Escutcheon with Quick-Mount feature may be used.

THIS INFORMATION APPLIES TO YOUR RECORDER ONLY:

Model # _____ Serial # _____

Date of Purchase: _____

Chart Paper Style: _____

CALIBRATION: 2133 2144 2166 _____

Temperature Range:
Single Channel _____

Dual: Chan. 1 _____ Chan. 2 _____
Actual Calibration Reading:
Single Channel Range _____

Dual: Chan. 1 _____ Chan. 2 _____

NOTES:

rustrak Instrument Div.
Gulton Industries Inc.
Municipal Airport • Manchester, N.H. 03103
Telephone (603) 623-3591 • Twx 710-220-1878

Chart Style A
Speed 1 in/hr
motor 2 rpm